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ORIGINAL ARTICLES.

I.—Bala Lake and the River System of North Wales.

By Philip Lake, M.A., F.G.S.

(With a folding Map, PLATE XI.)

(*Concluded from the May Number, p.* 215.)

Watersheds in other Valleys.

In North Wales there are several valleys which run parallel or nearly parallel to the valley of the Bala fault, and, like it, are crossed by watersheds which are quite inconspicuous. One of these watersheds separates the head of Cwm Prysor from the source of Afon Tryweryn; a second parts the springs of the Conway from those of Afon Dwyryd; and a third divides the waters of Nant Ffrancon from those of Afon Llugwy (a tributary of the Conway). (Pl. XI.)

In the first two cases the valleys are not deep, but they are sufficiently defined to form the lines chosen for the railway from Bala to Ffestiniog, and for the road from Ffestiniog to Denbigh; and in the third case, the valley is at least as striking as that of the Bala fault, and the watershed is even less conspicuous than that at Pant-gwyn.

All these watersheds lie upon one straight line—a line drawn from Pant-gwyn to a point 1,200 yards east of Llyn Ogwen. This may, indeed, be a mere coincidence, but the coincidence is remarkably close, and it seems more probable that the positions of the watersheds have been determined by some general cause.

It can scarcely be supposed that ever since the formation of these valleys (which are certainly pre-Glacial) the whole of Wales has remained absolutely fixed and immovable. And if the region has moved at all, there is little difficulty in supposing that the motion was not uniform throughout. A very slight differential movement, even now, would be sufficient to alter the positions of these watersheds; and it is quite possible, therefore, that their present positions have been fixed by former movements.

It may be remarked that this straight line crosses two other important valleys in which it does not coincide with the watersheds —the valley of Afon Lledr and Nant-y-gwryd. But this is easily explained if we suppose that the heads of these valleys stood too high to be affected by the differential movements. Moreover, in

each case there is some evidence that near to the spot where the line crosses, the rocky floor is higher than it is farther up the valley.

In the valley of Afon Lledr the line crosses a little way below Roman Bridge station. Above, the river flows through an alluvial flat: here, rocky spurs run down to the stream, and the stream itself flows over rock *in situ*.

Nant-y-gwryd is crossed near Dyffryn Mymbyr. The stream flows over a drift-covered flat; but at this point a line of rocky knolls rises through the drift.

These, then, are perhaps attempts at watersheds, frustrated by the fact that the heads of the valleys lay at a higher level. I am not, however, disposed to attach much importance to these unfinished watersheds, until the ground has been more closely examined. The evidence is somewhat doubtful, and near Roman Bridge it is possible that the river has forsaken its ancient channel.

Development of the River System of North Wales.

Among the most striking features in the topography of North Wales are the long deep valleys which run from north-east to south-west, and which, where they enter the sea, form the wide estuaries of the Mawddach, Dyfi, etc. Many of these valleys are dry for a considerable part of their course, or are occupied only by little streamlets out of all proportion to their own size. They are crossed by the principal watersheds of the district, and even at these points the floors of the valleys are comparatively low. They are not perfectly straight, but generally form curves of long radius, the convexity of which faces the south-east. (Pl. XI.)

Sometimes, at least, the valleys coincide with lines of fault; and in one case, as I have shown, two faults form a trough for a certain distance, and the floor of the valley coincides with the bottom of the trough.

My examination of the region not being by any means complete, I do not attempt upon the accompanying map to trace these valleys continuously across the district; but have merely indicated by heavy broken lines the principal streams, or portions of streams, flowing in valleys which I believe to belong to this N.E.–S.W. system. The continuity of the valleys is nevertheless sufficiently evident, although not quite so clear as it is in the field.

Among the most important of these valleys, or—to make less of an assumption—of these lines of valleys, are the following:—

1. The Menai Straits.

2. The estuary Traeth-bach, Afon Dwyryd, Cwm-tegwel, Afon Machno.

3. Mawddach estuary, Afon Wnion, Afon Dyfrdwy below Pantgwyn, Bala Lake, Afon Meloch, River Alwen from Maerdy to Bettws Gwerfil Goch, and possibly a part of the Clwyd.

The Mawddach estuary is not in a line with the general direction of the Wnion. A valley in more direct continuation of the latter is that in which lies the high road from Dolgelly to Towyn.

4. Valley of Tal-y-llyn and the Towyn Railway. Nearly in line with this, but apparently quite disconnected, is the Valley of the Dee between Llandderfel and Corwen, and the valley of Nant Morwynion.

5. Afon Dyfi up to Cemmaes, and perhaps to the source of the river.

6. River Banw from Llanfair to its junction with the Vyrnwy; then the Vyrnwy to its junction with the Tanat. The rivers Ceiriog and Dee below Chirk perhaps belong to this valley.

7. River Severn from Llanidloes to its junction with the Tanat.

Among the smaller valleys belonging to this system are (*a*) Cwm Prysor and Afon Tryweryn above its junction with Afon Gelyn, and (*b*) a small part of the Vyrnwy below the Liverpool Waterworks, River Marchnant, River Ceiriog from Llanarmon Dyffryn Ceiriog to Llansantffraid Glyn Ceiriog. Other shorter valleys of similar character and direction undoubtedly exist, but these I have made no attempt to indicate.

A closer examination would certainly reveal more clearly the connection and continuations of some of these valleys: but enough is shown upon the map to prove that some at least of these lines of valleys are continued, with little or no interruption, for great distances.

That these valleys have exercised a profound influence upon the drainage of the country is quite clear, and most of the principal rivers lie in them. They cut up the country, more or less completely, into parallel strips; and the drainage of each strip is intercepted by one or other of these parallel valleys. In the most northerly strip, between the Menai Straits and Traeth-bach, most of the streams flow northwards. But in the others the greater part of the drainage of each strip falls into the valley lying south of it; while the streams which run northward are generally small and unimportant.

For instance, entering the valley of the Bala fault from the north, we have Afon Eden, Afon Lliw, Afon Llafar, Afon Tryweryn, the Ceirw, and the Alwen; while from the south, the most important is Afon Twrch in Cwm Cynllwyd.

The question then arises, was the drainage of each strip established independently, after the formation of the long valleys; or was the drainage established first, and the long valleys formed afterwards? In the former case there would, presumably, be no connection between the streams of adjacent strips; in the latter, we should expect the more important streams of one strip to have their representatives in the next.

Beginning with the streams which flow into the valley of the Bala fault from the north, we have first Afon Eden, with its tributary Afon Mawddach.[1] This important river runs southward till it enters the Mawddach estuary at Llanelltyd, where it turns suddenly almost at right angles. But if we continue the line of

[1] After the junction of these two the river is called the Mawddach. But the Eden is clearly the principal branch, inasmuch as it maintains its direction unchanged.

the Eden across the valley and over the opposite hills, it leads us into Afon Dulas. The Dulas maintains the same direction until it enters the valley of the Dyfi, where it also is deflected to the right. If we neglect this deviation and proceed in the same line, we come again upon another stream flowing in the same direction, namely, Afon Rheidol. This river runs southward as far as Devil's Bridge, where it in turn is suddenly deflected at right angles, so as to enter the sea at Aberystwith. But our line is continued still further by the upper part of the Ystwyth and the valley of the Teifi.

So exactly are all these rivers—the Eden, Afon Dulas, the upper parts of Afon Rheidol, and of the Ystwyth and the Teifi—in the same line,[1] that the valleys to which they belong seem all to be portions of one great valley, the head of which probably lay as far north as Blaenau Ffestiniog. This valley, according to my views, was subsequently broken up by the formation of the transverse valleys belonging to the N.E.-S.W. system.

Similarly, on the south-east side of the Bala fault, we find the continuations of Afon Lliw and Afon Llafar in the river which is now called the Vyrnwy; of Afon Tryweryn in the River Tanat; of the Ceirw (probably) in the Ceiriog; and of the Alwen, in the Dee below Corwen.

Another important stream south of the Bala fault is the Banw, and possibly the original head-waters of this are represented by the upper part of the Dyfrdwy.

The Banw, the Vyrnwy, and the Tanat, all enter the sixth of the N.E.-S.W. valleys given in the list on a previous page. The Banw and the Vyrnwy are deflected and flow along this valley; but the Tanat maintains its original course and even crosses the next transverse valley. The original continuation of the Banw is probably to be looked for in the lower part of Afon Rhiw and, across the Severn, in the Onny River.

If we assume that the Eden, Lliw, etc., were the upper portions of the valleys which I have endeavoured to trace, we must conclude that before the transverse valleys were formed—those which now run from north-east to south-west—a radiating system of drainage was established, the centre of which lay in the high ground at and near the present source of the Conway.[2]

This appears also to be the centre from which radiate the principal

[1] It will be noticed that this line is almost exactly parallel to the general trend of the coast of Cardigan Bay, a fact which seems to point to some community of origin.

[2] If the radial valleys existed before the formation of the transverse valleys, we might expect that where the lines joining the remnants of the radial valleys cross the intervening ridges, there should be a col or depression; and this is, indeed, very commonly the case. Moreover, opposite each important stream where it enters a transverse valley, there is generally a little valley running down from the col and entering the transverse valley on the opposite side. For example, opposite the point where Afon Lliw enters the valley of the Bala fault, a valley runs in from the col called Bwlch-y-pawl, which is situated at the head of the River Vyrnwy. Opposite Afon Tryweryn is the valley of the Hirnant, and from this we pass across a col into the head of Afon Tanat. Similarly, in the line of the Ceirw we find Afon Trystion entering the valley of the Dee from the opposite side; and from the head of Afon Trystion a decided depression leads us to the head of the Ceiriog.

tributaries of the Clwyd; the Conway itself; and the rivers of Snowdonia, which occupy Nant Ffrancon, the Vale of Llanberis, and the valley of Llyn Cwellyn. I am not, however, in a position to discuss this question more fully, nor am I prepared to assert that all these streams belong to the same radial system.

There is certainly one important river which seems to be exceptional, namely, the river which flows through the pass of Aberglaslyn.

But the broad outlines of the river history of North Wales seem to be clear. A radial system of drainage was established; and subsequently a series of transverse valleys was formed, which broke up the radial system into sections, and each of the main transverse valleys carries away the drainage of one or other of these sections.

The transverse valleys were, I believe, formed by faults, with an upheaval on one side; but further investigation is needed to elucidate this point. One of the faults appears to have assumed for some distance the character of a trough, with the consequent formation of a lake, which is now Bala Lake; and it seems that the development of this trough was subsequent to the original formation of the valley.

If it were not for these transverse valleys, the drainage system of North Wales would be very similar to that of the Lake District, and the Vale of Clwyd would be the analogue of the Vale of Eden in Cumberland.

Summary.

In the foregoing pages I have endeavoured to throw some light upon the formation of Bala Lake and to sketch the development of the present somewhat complicated river system of North Wales. The explanation suggested is simple and fairly consistent; but it is still, in many respects, hypothetical. This is especially the case, perhaps, with regard to the share attributed to the faults, in the production of the present topography of the country. On this and many other points, further research is certainly necessary. Yet from the evidence adduced, it seems that the following conclusions may, with some probability, be drawn :—

1. Bala Lake belongs to the same valley as the River Wnion; and the drainage of this valley formerly flowed into the sea near Barmouth.

2. Bala Lake and the rest of the valley as far to the south-west as Pant-gwyn lie in a trough between two faults, modified by other faults crossing the trough obliquely.

3. The position of the watershed in this and in several other similar valleys has been determined by earth-movements.

4. The original drainage system of North Wales was a radial system, the centre of which lay in the high ground around the sources of the Conway. Subsequently a series of transverse valleys was formed which divided the radial system into sections, and each of the principal transverse valleys now carries away the drainage of one of these sections. Bala Lake was formed in one of the transverse valleys, probably not at the same time as the valley itself, but at a somewhat later period.

II.—The Parent-rock of the Diamond. Reply to a Criticism.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

A SHORT time since Mr. G. Trubenbach, Managing Director of the Newlands Diamond Mine, West Griqualand, drew my attention to a notice by Professor Beck[1] of the paper which I read to the Royal Society last June, on the Parent-rock of the Diamond in South Africa, kindly sending me a translation of the original. As Professor Beck's criticisms are founded on such a travesty of my published opinions[2] that I can only suppose his knowledge of our language to be very imperfect, and as the hypothesis which he advances appears to me untenable, I ask permission to reply to the one and point out the improbability of the other.

1. Professor Beck objects to my terming the crystalline garnet-pyroxene rock, which sometimes contains diamonds, an eclogite, remarking,[3] "which, however, must raise doubts, as this name has hitherto been applied only to a similar mineral combination of crystalline schists (*schiefer*), while Bonney particularly emphasizes the eruptive nature in this instance." In my paper I took the precaution of stating that I was well aware doubts had been expressed in the past as to the origin of eclogite, but that after good opportunities of studying it I was convinced it was an intrusive igneous rock. That such doubts should have existed is not surprising. The significance of foliation was for long imperfectly understood, and as eclogite is generally associated with crystalline schists, and is not seldom foliated, it was supposed to have had a similar origin. In such cases it is a metamorphic rock, but not in the sense formerly implied by that word; the foliation (by no means universal) being only a superinduced structure, while the evidence of intrusion is sometimes conclusive. Eclogite formerly was left with sundry other little understood rocks in a kind of 'oddment' drawer.[4] Does this uncertainty in the past as to the genesis of a rock debar us from using its name afterwards when we are able to do it with more precision? Or does Professor Beck mean to say that the whole history of a rock, as well as its mineral composition and structure, must be known before we can give it a name? In both the latter this South African rock is truly an eclogite, and I maintain the name may legitimately be used for it, when ill-grounded uncertainties as to the genesis have been cleared up. What does Professor Beck mean to do with the olivine rocks (or peridotites) and the corresponding serpentines? There also a similar doubt as to origin formerly existed.

2. This, however, is a mere difference of opinion on a question of nomenclature. I pass on to one more important. Professor Beck criticizes, at too great a length for full quotation, my supposed

[1] Zeitschrift für Praktische Geologie, December, 1899.

[2] Proc. Royal Soc., lxv, p. 223.

[3] I quote from the translation sent to me by Mr. Trubenbach, though I have occasionally made a slight alteration in the terms used.

[4] See, for instance, Cotta on Rocks, translated by Lawrence, 1878, p. 310.

views in regard to the original home of the diamond. The more important part, however, runs as follows:—"He assumes that they (the garnet diopside boulders) are fractures from a much older rock, which, having been subjected to the same action as river boulders, were brought to the surface, *together with the kimberlite,* from a *fluviatile deposit,*[1] at a great depth. Quite naturally he now deduces the hypothesis that all the diamonds found in the kimberlite have their origin *in such diamantiferous soapstone formation* (*diamantseifen*) *deposited in the depth of the Karoo formation* and brought to the surface by the same eruptive agencies as produced the kimberlite necks (stocks)." Professor Beck then proceeds to argue against the probability of these "diamantiferous soapstones" underlying the whole of the Karoo formation. But I never even mentioned a soapstone, and do not know what Professor Beck means by it, unless it be the matrix of the so-called kimberlite; neither have I ever asserted anything like the sentences which I have placed in italics. I agree with him that the existence of a bed of "diamantiferous soapstone" at the base of the Karoo (i.e. in the Dwyka conglomerate) is most improbable, but of that he is the sole inventor, and I strongly object to having such nonsense fathered upon me. I have read my paper again, and think, speaking from some experience as a writer, that it ought to be intelligible to anyone who really understands English. I did not, indeed, elaborate every minute detail of the argument.[2] For this I had two reasons—one, that as I was addressing scientific experts, they did not require elementary instruction; the other, that, as I personally object to elaborate demonstrations of the obvious, or to being told with much detail that Queen Anne is dead, I abstain, as far as possible, from inflicting this penance on others. What I said amounted to this,—that the diamond had now been found as a constituent of a coarse-grained eclogite; that this eclogite no doubt formed part of an old crystalline floor, underlying the Permo-Triassic deposits, from which fragments must have been broken off and rolled by water action into boulders; that these probably had been inmates of the Dwyka conglomerate; that after the Karoo Beds were deposited, volcanic explosions had shattered much of the crystalline floor (eclogites, peridotites, etc., some of them diamantiferous), and sent its fragments flying up together with the overlying Dwyka conglomerate[3] and Karoo Beds; and that the pipe was ultimately filled up with this broken material, which was subsequently exposed to solfataric, perhaps also very locally to contact action.

Thus Professor Beck is criticizing an hypothesis which is none of mine, but of his own imagining. From this I turn to the one which he proposes as a substitute. "We take the garnet diopside lumps, notwithstanding their form, not as actual boulders, but of

[1] The italics are mine.

[2] My views will be found on pp. 235, 236.

[3] The boulders, pebbles, and mineral grits in this would be scattered like shot from a gun.

intra-telluric origin, i.e. concretions of the kimberlitic magmas. They hold the same position to kimberlite as the well-known olivine lumps (*olivinknollen*), which sometimes have the same rounded-off form and smooth surface, to the basalt in which they are inclosed." To this I reply that: (1) I have spent some time in the endeavour to prove that kimberlite is only a fragmental rock,[1] and the occurrence in any peridotite of coarsely crystalline 'concretions' of garnet, diopside, enstatite, etc., would be without precedent. (2) It has yet to be proved that these 'olivinknollen' in basalt are 'concretions,' and I do not envy the man who attempts the task. I have examined scores of them; they are seldom, if ever, really well rounded, and are, I believe, fragments of a peridotite, caught up by the basalt, as happens to pieces of granite, gneiss, sedimentary and other kinds of rock. If the lumps of eclogite are concretions it is strange they should be so easily separable from the enclosing 'kimberlite,' and still more so that the minerals at their surface should so often be cut through exactly as they would be by attrition. In other words, speaking from a wide experience in the field, I am certain that these are as truly boulders as any in the bed of an Alpine torrent. But Professor Beck, apparently not quite satisfied with his 'concretion' hypothesis, goes on to suggest that rounding "may be accounted for by a rotatory abrasion during the eruption in the crater." I have examined the materials of a good many volcanic cones, but never saw such perfect rounding as this, and as I foresaw the possibility of that hypothesis being advanced, was careful to insert a sentence to show that I had both considered and rejected it. Thus I find myself unable to admit either the justice of Professor Beck's criticisms or the reasonableness of his hypothesis. The latter, indeed, suggests to me that its inventor has heard the "mouse squeak" more often than "the lark sing."

III.—Derived Limestones.

By Professor W. J. Sollas, D.Sc., F.R.S.

MY attention has been directed to the following paragraph, which appears in Mr. H. B. Woodward's monograph on the Jurassic Rocks of Britain, vol. iii, p. 31 (1893). It is as follows:—

"Prof. Sollas has suggested that rivers sometimes bear to the sea considerable quantities of undissolved calcareous matter, derived from the formation through which they flow. This is a matter that requires confirmation, for it is known that carbonate of lime is more readily soluble in fresh-water than in sea-water."

The statement attributed to me was more than a mere suggestion, and as the subject is of some interest it may be as well if I now present the evidence which I had in mind when asserting that the

[1] I do not deny—nay, I expect—that large masses of peridotite (probably also diamantiferous) exist in the crystalline floor, but not 'kimberlite' as defined by Professor Carvill Lewis. A little lower down, Professor Beck seems to admit the 'kimberlite' to be a breccia. If so, how can it be a 'magma,' unless he means that the unbroken material exists somewhere down below, in which case it is not likely to be 'kimberlite,' but some ordinary variety of peridotite.

denudation of a limestone and the transportation of calcareous sediment may be accomplished not only by solution but by the mechanical action of fresh-water.

On examining under a microscope the suspended matter which floats in the river Cam above Cambridge, and which may readily be separated by filtration through a muslin net, the observer who looks upon them for the first time will be surprised to find associated with a number of minute living organisms certain bodies which resemble in the closest manner the coccoliths of the Chalk. The appearance of these is so fresh that it would not be an altogether inexcusable blunder to regard them as native to the stream, and though it might be objected that fresh-water coccoliths are things hitherto unheard of, yet an answer to this might be found in the fact that on removing the calcareous part of the organism with dilute acid a soft granular film remains behind, which has not only a very organic appearance, but readily stains with magenta and some other aniline dyes.

On pushing the enquiry further, however, it will be found that the residual film is not affected by such stains as are selective in their effects; those which only react upon protoplasm have no effect upon it. Further, the coccoliths give no signs of life; they cannot be made to grow nor to subdivide by fission.

In the old days when the coprolite pits around Cambridge were being worked it was not uncommon to come across streams of chalky water flowing away from the washing tanks. An examination of this revealed all the forms of coccoliths which were to be found floating in the Cam, but in this case there could be no question as to their origin, they were derived from the chalk marl.

Considering, then, that no independent evidence can be cited for the existence of fresh-water coccoliths, that the minute bodies floating in the Cam present no signs of life, and that the river drains a country largely composed of chalk rocks, from which, as we have proof, coccoliths may be derived, the presumption is altogether in favour of regarding the coccoliths of the Cam as mechanical sediments now in process of being carried to the sea.

I have said that these sediments may be "considerable." A good deal depends on what is meant by considerable, but I think the qualification may be justified by the following example. On visiting the gravel-pits at Barnwell occasional white lenticular beds may be observed intercalated amid the finer sands of the deposit. These are composed of carbonate of lime, and a microscopic examination proves them to consist of minute organisms and débris of organisms, which have been derived from the chalk. Foraminifera, whole and broken, of which *Globigerina* is one of the commoner forms, shell prisms, and coccoliths are obvious. Thus we learn that not only may a river transport calcareous sediment, even when constituted of such minute bodies as coccoliths, just as it might an insoluble clay, but further, that under favourable circumstances it may deposit this material and thus form beds of limestone, which are not immediately but only indirectly of organic origin.

It was partly from observations such as these that I was led to suggest a derivative origin for the calcareous substance of the cornstones of the Old Red Sandstone, and for much of the limestone of the Lower Lias; nor has subsequent reflection led me to abandon this explanation, but rather to extend it. A good deal of the magnesian limestone of the North of England is as false-bedded as a modern beach sand, and occurs under circumstances that would lead us to look for its source rather in the mountain limestone than in its poverty-stricken indigenous fauna. Such derivative calcareous matter would by reason of its finely divided state be in a condition to yield readily to the action of magnesian waters and thus pass into dolomite.

It by no means follows that rivers have been the only agents by which mechanical calcareous deposits have been formed from pre-existent limestones; sea waves may have also played their part, as, indeed, is suggested by my friend Mr. Woodward, who also has arrived at the conclusion "that under certain conditions there may be sedimentary deposits of calcareous mud [derivative] as well as chemical precipitates."

IV.—Woodwardian Museum Notes: On the British Species of the Genus *Conocoryphe*.

By F. R. Cowper Reed, M.A., F.G.S.

In 1877 Dr. Woodward[1] recorded nineteen British species of the genus *Conocoryphe*, of which seven were doubtful. The following is the list of them:—

Conocoryphe abdita, Salter.
C. applanata, Salter.
C.? bucephala, Belt.
C. bufo, Hicks.
C. coronata, Barrande.
C. (*Solenopleura*) *depressa*, Salter.
C. Homfrayi, Salter.
C. humerosa, Salter.
C. invita, Salter.
C.? longispina, Belt.
C. Lyellii, Hicks.
C.? olenoides, Salter.
C.? simplex, Salter.
C. solvensis, Hicks.
C. sp., Salter.
C.? variolaris, Salter.
C.? verisimilis, Salter.
C. vexata, Salter.
C.? Williamsoni, Belt.

Professor Etheridge[2] in 1888 gave the following four additional species:—

Conocoryphe Malvernius, Phillips.
C. monile, Salter.
C. perdita, Hicks.
C. Plantii, Salter.

Salter[3] in 1872 had doubtfully recorded *C.? ecorne* (Angelin)? from Wales. The latest addition to the list was *C. viola* (H. Woodward) in 1888 from Bethesda.[4]

Since the generic name *Conocoryphe* is now used in a much more restricted manner than formerly, it is desirable that the true position of the above-mentioned species should be determined afresh. The genus *Conocoryphe* is now used[5] as the type of the family

[1] Catal. Brit. Foss. Crust., pp. 31–33.
[2] Brit. Pal. Foss., pp. 48, 49, and 406.
[3] Catal. Camb. Sil. Foss. Woodw. Mus., p. 12.
[4] H. Woodward, Q.J.G.S., vol. xliv (1888), p. 74, pl. iv.
[5] Textbook of Palæontology, by Zittel & Eastman (1900), vol. i, p. 626.

Conocoryphidæ, which also includes the genera *Atops*, *Ctenocephalus*, and *Bathynotus*, besides others of subgeneric rank or of less importance. The characters of the family are given (op. cit.) as follows :—

"Free cheeks very narrow, forming the lateral margins of the cephalon, and bearing the genal spines. Fixed cheeks large, usually traversed by an eye-line extending from near the anterior end of the glabella. Facial sutures running from just within the genal angles, curving forward, and cutting the anterior lateral margins of the cephalon. Eyes rudimentary or absent. Thorax with from fourteen to seventeen segments. Pygidium small and of few segments. Cambrian."

The characters of the genus *Conocoryphe* are given as follows :—"Cephalon semicircular; genal angles produced into spines; glabella distinctly lobed, wide behind, and contracted in front, not extending to the frontal border. Fixed cheeks very large, with conspicuous furrow parallel to the anterior margin; free cheeks narrow, marginal; thorax of fourteen segments."

The same author, Dr. Charles Beecher, who has written the article on trilobites in the book above quoted, published the same diagnosis of the family Conocoryphidæ in 1897,[1] and included in it the following genera and subgenera :—

Conocoryphe, Corda (= *Conocephalites*, Barrande).
Aneucanthus, Angelin.
Atops, Emmons.
Avalonia, Walcott.
Bailiella, Matthew (= *Salteria*, Walcott, and *Erinnys*, Salter).
Bathynotus, Hall.
Carausia, Hicks.
Ctenocephalus, Corda.
Dictyocephalus, Bergeron.
Eryx, Angelin.
Harttia, Walcott.
Toxotis, Wallerius.

Matthew[2] has contributed much to our knowledge of the genus, and his writings deserve careful study.

The usage of the generic name *Conocoryphe* in Britain has on a previous occasion been briefly criticized by the present author,[3] and some of the British species assigned to other genera. In discussing them here more in detail it will be convenient to take them alphabetically.

Conocoryphe abdita (Salter, Mem. Geol. Surv., vol. iii, 1866, p. 306, pl. v, fig. 13).—This species is at once seen to possess fundamental differences from *Conocoryphe*, sens. str., in the large well-developed eyes and in the course of the facial suture. The presence of pits in the marginal furrow of the head-shield suggests that it should be referred to either *Euloma* or *Apatokephalus*, and the position of the eyes, their relative size, the eye-lines, and the

[1] Amer. Journ. Sc., vol. iii (1897), p. 180.
[2] Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv, pp. 102, 103.
[3] Geol. Mag., Dec. IV, Vol. V (1898), pp. 495, 496.

course of the facial suture indicate that it belongs to the former genus, *Euloma*. Linnarsson and Brögger[1] assigned it many years ago to this genus.

C. applanata (Salter, Brit. Assoc. Rep., 1865, p. 285; Q.J.G.S., vol. xxv, 1868, p. 53, pl. ii, figs. 1–5).—In the first place the presence of eyes and the course of the facial suture remove it from *Conocoryphe*, sens. str. The characters of *Solenopleura*, which Matthew[2] has tabulated, agree in many particulars with those present in this form. The surface is granular or subtuberculate, the glabella is prominent, the dorsal furrows well defined, the genal angles are pointed, the fixed cheeks are strongly swollen, and the pygidium is small with but three segments. The rather remote eyes, with the ocular ridges, the parabolic glabella, the course of the facial sutures, the strong margin to the head-shield, and the marginate pygidium are also points in which *C. applanata* agrees with *Solenopleura*. The tubercle on the neck-segment found in the latter genus is also present in the type-specimen, though not mentioned in Salter's description. The pleuræ, however, of this species are said to be pointed, while in *Solenopleura* Matthew (op. cit.) describes them as bluntly rounded. All the specimens of *C. applanata* which I have examined appear to have had blunt tips to the pleuræ, the pointed appearance being due to oblique crushing or distortion. The weight of evidence is therefore in favour of assigning this form to the genus *Solenopleura*.

C.? bucephala (Belt, Geol. Mag., Vol. V, 1868, p. 10, Pl. II, Figs. 1–6).—This species is certainly not a true *Conocoryphe*, as a brief inspection of the figures shows. The general characters of the species place it amongst the Olenidæ, and it may provisionally be assigned to the genus *Olenus*. The crust of the glabella is said to be unfurrowed as in *Angelina* and *Cyclognathus*, but when this is removed or the glabella crusted two or three pairs of furrows are seen. The triangular margin of the frontal lobe is peculiar, and since the pygidium is also unknown its true generic position must for the present remain a matter of doubt.

C. bufo (Hicks, Brit. Assoc. Rep., 1865, p. 285; Q.J.G.S., vol. xxv, 1868, p. 52, pl. ii, fig. 8).—This is a true *Conocoryphe*, sens. str., as has been previously remarked.[3] It appears to belong to the subgenus *Bailiella* (Matthew), of which *C. Baileyi* (Hartt) is the type, and which is characterized by the facial suture cutting off a third of the marginal fold instead of running along the outer edge of this fold as in *C. Sulzeri*. Matthew (op. cit.) remarks that *C. bufo* possesses a head-shield very like that of *C.* (*Bailiella*) *elegans* (Hartt), but the pygidium is not known. Linnarsson[4] had previously

[1] Die Silur., Etag. 2 and 3 (1882), p. 98.

[2] Trans. Roy. Soc. Canada, vol. v (1887), p. 134.

[3] Matthew, Trans. Roy. Soc. Canada, vol. ii (1884), sect. iv, pp. 102, 103; Reed, Geol. Mag., Dec. IV, Vol. V (1898), pp. 495, 496.

[4] Sver. Geol. Undersokn., 1877, Om fauna i lagren med *Paradoxides ölandicus*, p. 16, t. 2, f. 2–4; Sver. Geol. Undersokn., ser. c, No. 35, 1879, Om faunan i Kalken med *Conocoryphe exsulans*, p. 19, t. 2, f. 26–28.

noticed the resemblance of the British species to *C. Dalmani* (Sjogren), which may be identical with *C. emarginata* (Linn.).

C. coronata, Barrande (Syst. Sil. Bohême, vol. i, 1852, p. 424, t. 13, f. 20–26). — This species was first described from Britain by Hicks.[1] The type-specimen is in a poor state of preservation, and there may be some doubt if it really belongs to Barrande's species; but Salter's remark [2] that while Hicks' specimen possesses genal spines Barrande's figure shows none, is of no importance, as Barrande's figure was drawn from a specimen without the free-cheeks. Genal spines are characteristic of the genus *Ctenocephalus* (Corda), to which *C. coronatus* belongs, as Matthew (op. cit., p. 103) has pointed out. *Ctenocephalus* is distinguished from *Conocoryphe* (type *C. Sulzeri*) by the possession of a marked protuberance—a frontal lobe—in front of the glabella, and by a smaller pygidium. The number of thoracic segments is also not the same, and the course of development is different. The distinction of these two genera therefore appears to be well founded.

C. (*Solenopleura*) *depressa*, Salter (Siluria, 2nd ed., 1859, p. 47, Foss. 7, fig. 2 [*Ellipsocephalus*]). — Brögger [3] has expressed the opinion that this species belongs to the subgenus *Cyclognathus* of the genus *Olenus*. But the presence of genal spines, the more remote and more backward position of the eyes, the glabellar furrows, the relative shortness of the glabella itself, the possession of a rather wide frontal limb separating it from the margin, and the different shape of the head-shield, are opposed to this view. The form of the pleuræ is certainly somewhat similar, and the number of body-segments is the same, while the pygidium bears a very close resemblance. But a comparison with specimens of the type form *Cyclognathus costatus* from Vestfossen presented by Professor Brögger himself to the Woodwardian Museum confirms my opinion that *C. depressa* cannot be referred to *Cyclognathus*. With *Solenopleura* its affinities are rather closer. The number of body-segments is the same and the pygidium and pleuræ are fairly similar, but the fixed cheeks show no sign of having been swollen, the genal angles are pointed and have no submarginal spine, the eyes are rather forward, and there is no neck tubercle nor granulation of the surface. Matthew, in a manuscript note on the specimens of this species in the Woodwardian Museum, considers it to be allied to *Solenopleura*. Its precise generic position must for the present remain uncertain, though it must be removed from *Conocoryphe*. With the exception of the shape of the pleuræ it has many points of similarity to *Olenus*, sens. str., and it undoubtedly belongs to the family Olenidæ.

C. ? *ecorne*, Ang.? (Salter, Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 12), is a species of *Peltura*, and shows all the characteristic features of that genus.

C. Homfrayi, Hicks (Q.J.G.S., vol. xxviii, 1872, p. 178, pl. vi, fig. 12).—The type-specimen is much compressed and distorted, and

[1] Q.J.G.S., vol. xxviii (1872), p. 178, pl. vi, fig. 11.
[2] Mem. Geol. Surv., 2nd ed. (1881), vol. iii, p. 409.
[3] Die Silur., Etag. 2 and 3 (1882), p. 111.

after a careful examination of it I have much doubt[1] if eyes really existed, though the species has been described as possessing them. The number of thoracic segments and the shape of the pleuræ are the same as in *Conocoryphe*, sens. str., and the genal angles similarly bear spines. The pygidium, according to Hicks, has fewer segments than in *C. Sulzeri*, but the state of preservation of this member is very poor. With much probability this species may therefore rightly be left in the genus *Conocoryphe*.

C. humerosa, Salter (Rep. Brit. Assoc., 1865, p. 285; Q.J.G.S., vol. xxv, 1868, p. 54, pl. ii, fig. 7).—The specimen on which this species was founded has the head-shield very much crushed, and the characters given by Salter (op. cit.) are very imperfectly seen, so that not much weight can be attached to them. The ornamentation of the crust is, however, distinct, and the neck-spine is preserved fairly well. The portion of the thorax is nearly perfect, and all the features mentioned by Salter can be made out, as well as some others not recorded. But all the characters are absolutely different to any found in the thorax of any species of *Conocoryphe*, sens. str., and it can be positively asserted that it does not belong to this genus. The spine on the neck-segment, followed by those on the axial rings of the thorax, the shape, the groove, and free spinose ends of the pleuræ suggest the genus *Olenoides*. The peculiar radiate "venulose lines" and granulation ornamenting the surface of *O. typicalis* (Walcott) described by Walcott[2] are distinctly visible on the head-shield of the type-specimen of *C. humerosa*; and comparison with specimens of *Olenoides* from America shows that the spines on the axis closely resemble those in *O. typicalis*, while the pleuræ are more like those of *O. nevadensis* (Meek). The geological age of the beds in which *Olenoides* occurs is approximately the same as that in which *C. humerosa* was found, and there seems to be no reason for hesitating to ascribe this species to the genus *Olenoides*.

C. invita, Salter (Dec. Geol. Surv., 1865, pl. vii, fig. 6).—This species has been referred by Brögger[3] to his new genus *Apatokephalus*, as I have recently mentioned.[4] The characteristic features of this genus, which shows many points of resemblance to *Euloma* and *Dicellocephalus*, are well exhibited in the head-shields of this form, and Brögger's view needs no further comment.

C.? longispina, Belt (Geol. Mag., Vol. V, 1868, p. 9, Pl. II, Figs. 12–14).—By the characters of the head-shield we can at once decide that this species does not belong to *Conocoryphe*. Judging from Belt's figures and description, it may without hesitation be referred to the genus *Olenus*, and probably to its subgenus *Parabolinella*, as indicated by the course of the facial suture and position of the eyes, but the shortness of the glabella is remarkable.

C. Lyelli, Hicks (Q.J.G.S., vol. xxvii, 1871, p. 339, pl. xvi, figs. 1–7).—On a former occasion[5] I have stated that this species is

[1] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.
[2] Bull. U.S. Geol. Surv., No. 30 (1886), p. 180, pl. xxv, figs. 2, 2*a*, 7.
[3] Nyt Magazin fur Naturvidenskaberne, Bd. xxxv (1896), pp. 179–185, 200.
[4] Geol. Mag., Dec. IV, Vol. VII (1900), p. 46.
[5] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.

probably a true member of the genus *Conocoryphe*. The narrow marginal free-cheeks, the course of the facial suture, the absence of compound eyes, the number and characters of the thoracic segments, are features in which it completely agrees.

C. malvernius, Phillips ("Geology of Oxford," 1871, p. 68, fig. 5).—As far as the imperfect figure allows one to judge, this species appears to belong to the genus *Peltura*. At any rate, it is not a *Conocoryphe*, but is referable to one of the Olenidæ.

C. monile, Salter (Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 32; Callaway, Q.J.G.S., vol. xxxiii, 1877, p. 665, pl. xxiv, fig. 4).—This species, which was first described by Callaway (op. cit.), has been assigned to the genus *Euloma* by Brögger,[1] of which it exhibits all the typical features.

C.? olenoides, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 308, pl. viii, fig. 6).—It is quite doubtful to what genus this species should be referred, but we cannot have any hesitation in removing it from *Conocoryphe* and placing it amongst the Olenidæ.

C. perdita, Hicks (Q.J.G.S., vol. xxv, 1869, p. 53, pl. ii, fig. 3).—This species has never been fully described, and the only published figure of it is most unsatisfactory. Hicks (op. cit.) says *C. bufo* is its nearest ally, and if this be the case it must probably be a true *Conocoryphe*.

C. Planti, Salter (Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 11).—This species, founded on well-preserved specimens, is an excellent example of the subgenus *Parabolinella* of the genus *Olenus*, and a description of it is now in the press. Salter (op. cit.) assigned it correctly to *Olenus*.

C.? simplex, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 306, pl. v, fig. 17).—The smooth glabella, the very forward position of the eyes close to the front end of the glabella, and the course of the facial suture agree well with *Cyclognathus*, to which it may be referred.

C. solvensis, Hicks (Q.J.G.S., vol. xxvii, 1871, p. 400, pl. xvi, fig. 8).—I have previously[2] referred this species to *Ctenocephalus*, and probably it belongs to its subgenus *Hartella*, as Matthew[3] has remarked, and resembles *C. Matthewi*, Hartt. A Scandinavian species which is very closely allied, or may be only a variety of *C. solvensis*, is *Conocoryphe exsulans*, Linnarsson.[4]

C.? variolaris, Salter (Q.J.G.S., vol. xx, 1864, p. 236, pl. xiii, figs. 6, 7).—The characters of the head-shield, eyes, and facial sutures at once remove it from *Conocoryphe*, sens. str. Salter compares it to *C. Ribeiro*, Barrande, and also mentions that in some respects it resembles the genus *Sao*. But the lobation of the glabella is very different to that in *Sao hirsuta*, and the genal angles are furnished with definite spines, turned slightly outwards,

[1] Die Silur., Etag. 2 and 3 (1882), p. 98.
[2] Geol. Mag., Dec. IV, Vol. V (1898), p. 495.
[3] Trans. Roy. Soc. Canada, vol. ii (1884), p. 103.
[4] Sver. Geol. Undersokn., ser. c, No. 35, Om Faunan i Kalken med *Cono. exsulans* (1879), p. 15, t. ii, f. 21, 22.

and not merely pointed as in that species. The eye is also smaller, and there is no ocular ridge. There are seventeen body-segments in the adult *Sao*, while in *C.* ? *variolaris* there are only thirteen preserved, with traces of a fourteenth. The tuberculation bears, however, a somewhat close resemblance, but this feature is not of much importance in determining affinities.

On the other hand, the lobation of the glabella corresponds with that described by Angelin[1] for *Solenopleura*, and there is also a coarse though not so abundant tuberculation of the head-shield in some of the Scandinavian species. The genal angles in *Solenopleura* appear to have typically borne similar spines. The convexity of the fixed cheeks which Matthew (op. cit.) emphasizes, also existed in *C.* ? *variolaris*, as their cracked surface shows, and in the type-specimen it is crushed in. The tubercle on the neck-segment is also present as in *Solenopleura*. Though in the description of the species it is said the pleuræ have pointed ends, yet in the type-specimen they are certainly rounded so far as they are preserved.

On the whole, it does not seem to be unnatural to assign this species provisionally to the genus *Solenopleura*.

C. ? *verisimilis*, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 308, pl. vi, fig. 13).—Brögger[2] has suggested that this species may belong to *Cyclognathus*; but though the forward position of the eyes seems to favour this view, the shape of the free-cheeks with their pointed genal angles forbids its acceptance. The general appearance of the form is that of an immature individual of *Angelina Sedgwicki*; but it may be a distinct species. There are only twelve body-rings instead of fifteen; the genal spines are much shorter, and the eyes are more forward and nearer the front end of the glabella; but all these characters might be due to immaturity. The pygidium is unknown, but the thoracic segments have similar characters; and it may be with much confidence referred to the genus *Angelina*.

C. vexata, Salter (Mem. Geol. Surv., vol. iii, 1866, p. 307, pl. viii, fig. 7).—Though this species is obviously not a member of *Conocoryphe* as now defined, its true generic position is doubtful. Perhaps it belongs to the Olenidæ, but even this is uncertain.

C. viola, Woodward (Q.J.G.S., vol. xliv, 1888, p. 74, pl. iv).—The figures and description of this form suffice to remove it from *Conocoryphe*, sens. str., but its features, especially its facial sutures, are so peculiar that a new generic title seems requisite.

C. ? *Williamsoni*, Belt (Geol. Mag., Vol. V, 1868, p. 9, Pl. II, Figs. 7–11).—This species belongs to the Olenidæ and probably to the subgenus *Parabolinella* of the genus *Olenus*; the course of the facial sutures, the position of the eyes, and other characters of the head-shield correspond, but only two pairs of furrows on the glabella are described. The thorax rather more resembles that of *Olenus*, sens. str., than that of *Parabolinella*, and the pygidium is

[1] Pal. Scand., 1854, p. 26.

[2] Die Silur., Etag. 2 and 3 (1882), p. 111.

somewhat peculiar, though in the complete margin and number of segments it agrees with *Parabolinella*. To *Olenus* used in a generic sense this species may certainly be referred. Salter's [1] species with the same name is distinct from Belt's, but belongs to the Olenidæ.

From the above revision the so-called species of *Conocoryphe* in Britain should be designated as follows :—

Euloma abditum.
Solenopleura applanata.
Olenus? bucephalus.
Conocoryphe (Bailiella) bufo.
Ctenocephalus coronatus.
Solenopleura? depressa.
Peltura, sp. [= *C.? ecorne*? (Ang.), Salter].
Conocoryphe? Homfrayi.
Olenoides humerosus.
Apatokephalus invitus.
Olenus (Parabolinella?) longispina.
Conocoryphe Lyelli.
Peltura? malvernia.
Euloma monile.
Conocoryphe? perdita.
Olenus (Parabolinella) Planti.
Olenus (Cyclognathus) simplex.
Ctenocephalus (Hartella) solvensis.
Solenopleura? variolaris.
Angelina verisimilis.
Olenus (Parabolinella?) Williamsoni.

The three species of which the genera even are doubtful are *C.? olenoides*, *C. vexata*, and *C. viola*. But none of these three can be attributed to *Conocoryphe*, and their true position must be left to the future to decide.

The distribution of the tabulated forms is as follows :—

HARLECH SERIES.
Conocoryphe Lyelli.
Ctenocephalus (Hartella) solvensis.
MENEVIAN.
Solenopleura applanata.
Conocoryphe (Bailiella) bufo.
Ctenocephalus coronatus.
Conocoryphe? Homfrayi.
Olenoides humerosus.
Conocoryphe? perdita.
Solenopleura? variolaris.
LINGULA FLAGS.
Euloma abditum.
Olenus? bucephalus.
Peltura, sp.
Apatokephalus invitus.
Olenus (Parabolinella?) longispina.
Peltura? malvernia.
Olenus (Parabolinella) Planti.
Olenus (Cyclognathus) simplex.
Olenus (Parabolinella?) Williamsoni.
TREMADOC.
Solenopleura? depressa.
Euloma monile.
Angelina verisimilis.

The genus *Conocoryphe*, sens. str., is thus seen to be confined in Britain to the Lower and Middle Cambrian beds.

V.—On the occurrence of a Blue Amphibole in a Hornblende Kersantite from Co. Down.

By HENRY J. SEYMOUR, B.A., F.G.S., of H.M. Geological Survey of Ireland.

(Communicated by permission of the Director-General.)

IN connection with the revision of the Silurian area in Ireland, at present in progress by the staff of the Irish branch of the Geological Survey, a number of rock-specimens of the dykes occurring on the coast of Co. Down were lately petrographically examined by the writer, who detected in one of the slices a *blue* amphibole of secondary origin. As a mineral of this kind was not hitherto known to occur *in sitú* in Ireland, it may be of interest to put its discovery on record here and to give also a few details respecting its characteristics.

[1] Cat. Camb. Sil. Foss. Woodw. Mus., 1872, p. 12.

The rock in which it occurs appears as a dyke (in Upper Silurian sediments)[1] on the shore one-eighth of a mile south of the point where the letter *B* in South Bay is engraved on the map; three miles south-east of Portaferry (1″ sheet 49), and near the spot where the small road south of 'Tara Fort' reaches the coastline. On the original 6 inch working maps of the Survey it is represented[2] as a double dyke, with the ends of each portion in parallel contact, the northern limb forming a semicircular bend in the middle and enclosing a small area of sedimentary rocks. The combined width of the two portions is approximately 20 inches.

In the hand-specimen the rock is of a dull greyish-green colour, and possesses a medium-grained crystalline structure. Bronzy mica is the mineral most readily noticeable, and a few octahedra of magnetite may be seen with the aid of a pocket lens. Its specific gravity was found to be 2·85 in its present slightly decomposed condition. Under the microscope it is seen to consist essentially of a dark mica, with subordinate green hornblende, and an aggregate of felspar crystals. Accessory and secondary minerals also present are apatite, magnetite, a blue amphibole, chlorite, and several calcareous pseudomorphs, apparently after augite or hornblende phenocrysts, more probably the latter.

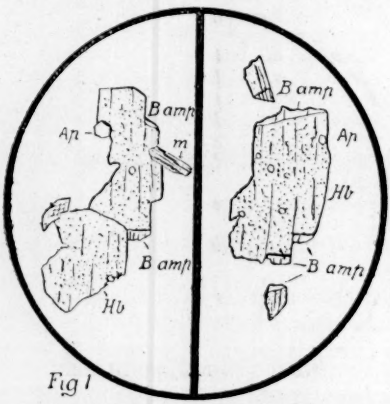


Fig 1

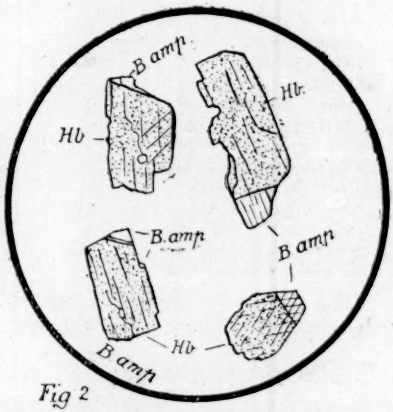


Fig 2

MINERALS.—*Hb.* green hornblende. *m.* biotite. *Ap.* apatite. *B. amp.* blue amphibole.

FIG. 1 shows two large hornblende phenocrysts, with additions of secondary blue amphibole on some of their terminal faces. × 45 diams.

FIG. 2 shows four crystals which exhibit the typical mode of occurrence of the blue amphibole. That in the S.E. quadrant shows a basal section with the clinopinacoid of the primary green hornblende replaced by the blue amphibole. The crystal in the S.W. quadrant shows a narrow pale-blue zone between the green hornblende and the normal blue amphibole. × 45 diams.

[1] These sediments were originally regarded as Lower Silurian. The recent revision (by Mr. F. W. Egan), however, shows them to be Upper Silurian. Report of Director-General of Geol. Survey, Appendix to 44th Report, Dept. of S. and A., p. 365.

[2] By Mr. W. A. Traill, who mapped the dykes in this district. See Memoir of Geol. Survey to accompany 1″ sheets 49, 50, and 61 (1871), pp. 6 and 43.

The biotite forms small (about 0·40 mm.) hypidiomorphic crystals scattered fairly abundantly and evenly throughout the slide. Sections at right angles to the cleavage planes are strongly dichroic (almost colourless to greenish brown), and are frequently bent into curved forms. Narrow bands of calcite are occasionally noticed between the lamellæ. The mineral is here and there altered to chlorite on its edges, and also to a less extent along cleavage cracks. Sections parallel to the basal plane give a uniaxial interference figure and show an outer rim of a much darker colour than that of the interior of the crystal.

The felspars occur in medium-sized allotriomorphic crystals which are rather altered and mostly micropoikilitic with numerous minute inclusions. In their present condition the exact species is not satisfactorily determinable, but repeated twinning is noticeable in several of the less altered crystals, and they would seem to be essentially plagioclase.

Apatite is an abundant constituent in the rock, and occurs as inclusions in the biotite, plagioclase, and in the green hornblende.

This latter mineral is also hypidiomorphic, and appears to be slightly posterior in date to the biotite, small crystals of which it sometimes includes. Sections parallel to the principal axis attain a length of 0·60 mm. The pleochroism is fairly strong, the tints varying from yellowish to a dull dark green. Basal sections exhibit the characteristic six-sided forms with well-defined cross cleavages intersecting at an angle of about 124°. The blue amphibole occurs mostly as a secondary addition to, but partly also as a replacement of, the primary green hornblende, and has grown in crystallographic continuity with it. The cleavage lines are usually continuous in both varieties, but are finer and sharper in the blue amphibole. In most cases this latter is added to the clinopinacoidal or terminal planes of the green variety, and occurs also, but less often, along cracks in the interior of these crystals. The secondary enlargement is quite limited in extent and seldom exceeds 0·10 mm. in greatest length, the average being rather below this figure. The junction line between the two varieties is generally distinct, and they are also sharply marked off from one another by their notably different pleochroism. Exceptionally a very narrow band or zone of material of a much paler blue colour than the normal blue amphibole occurs between the latter and the green hornblende. The drawings show the characteristic mode of occurrence of the secondary mineral in question. Owing to its small size it does not present facilities for satisfactorily determining its optical properties, but in so far as it is possible to do so, they would appear to be as follows. Sections approximately parallel to the clinopinacoid show that the extinction angle is about 15°, and that this takes place on the opposite side of the vertical axis to that of the green hornblende to which it has been added. Observations with the quartz wedge appear to prove that this direction of extinction corresponds also with the axis of maximum elasticity. The pleochroism is strong and is as follows: a = sky-blue, b = pale reddish-violet, c = pale yellowish. The absorption formula is $a > b > c$.

In some isolated cases the blue amphibole shows wavy extinction under crossed nicols, due apparently to a gradual change in chemical composition during its formation. It was found impracticable to isolate material for chemical analysis, but there can be no reasonable doubt that it belongs to the soda amphibole group of which riebeckite and arfvedsonite are typical examples.

The occurrence of a secondary blue amphibole under conditions exactly similar to those just detailed above has been described by Dr. Whitman Cross[1] in the case of an allied rock from Colorado. A. C. Lane[2] also records a similar occurrence in a syenite from Michigan. More recently J. S. Flett[3] notes the presence of a secondary blue amphibole in cracks in crystals of hornblende in one of the lamprophyre dykes of the Orkney Islands. The mineral from the Co. Down corresponds so closely in every particular with those from the two American localities aboved cited, that the writer has little hesitation in referring it to the same species. The mineral described by Cross has been called crossite by Ch. Pelache,[4] who also has described a species with identical optical properties. Dr. Cross, however, in a later publication[5] states that the mineral in question is considered to be arfvedsonite by Dana,[6] Brögger,[7] and Rosenbusch.[8] It may be noted further that Iddings, in his translation[9] of Rosenbusch's work, describes the secondary amphibole of Cross in the context between glaucophane and riebeckite, which position the at any rate optically similar species of Pelache[10] occupies by virtue of its intermediate chemical composition. Rosenbusch[11] notes the occurrence of a blue amphibole in a minette from Wachenback in the Vosges, the rock belonging to the same group as the Co. Down specimen.

VI.—On *Rhadinichthys monensis*, Egerton, and its Distribution in the Yorkshire Coalfield.

By Edgar D. Wellburn, L.R.C.P., F.G.S., F.R.I.P.H., etc.

THIS species was first described by Sir P. De M. Grey Egerton[12] as *Palæoniscus monensis*, in 1850, from detached scales from the Coal-measures of Anglesey. Subsequently, Dr. R. H. Traquair[13] proved that the proper position of the fish was in his genus *Rhadinichthys*. Up to this date only detached scales had been known, but in the paper just mentioned Dr. Traquair described specimens showing many points in the structure of the fish which had been

[1] Amer. Journ. Sci., vol. xxxix (1890), p. 359 et seq.
[2] Amer. Journ. Sci., vol. xlii (1891), p. 505.
[3] Trans. Roy. Soc. Edinburgh, vol. xxxix (1900), pt. iv, p. 884.
[4] Bull. Dept. Geol. Univ. California, 1894, p. 181 et seq.
[5] 16th Ann. Rep. U.S. Geol. Survey, 1894–95, pt. ii, p. 30.
[6] System of Mineralogy, 6th edition, 1892, p. 402.
[7] Die Gesteine der Grorudit-Tinguait-Serie, 1894, p. 33.
[8] Die mikro. Phys. der petro. wichtigen Min., 3rd ed., 1892, p. 567.
[9] Translation of the last work by Iddings, 1898, p. 270.
[10] Loc. cit., p. 189.
[11] Mikro. Phys. d. massigen Gesteine, 1896, p. 510.
[12] Quart. Journ. Geol. Soc., vol. vi (1850), p. 5.
[13] Proc. Roy. Phys. Soc. Edinb., vol. iv (1878), p. 241.

hitherto unknown. In my collection there are many fragmentary remains, collected from the Yorkshire Coal-measures, which show, among other interesting points, the form and ornamentation of many of the bones of the head and shoulder-girdle; while one more nearly perfect specimen shows well the form of the fish and some other points in its anatomy which have not been hitherto described, namely, the relative positions of the dorsal, anal, and ventral fins, the former being very well preserved and perfect.

From the material above mentioned, together with that already described by Dr. Traquair, I now think it possible to give a fuller and more detailed description of the fish than has hitherto been possible.

One specimen in my collection, which shows the fish from a line drawn obliquely upwards and backwards from a point immediately behind the pectoral fin to a point slightly beyond the commencement of the caudal fin, would represent a fish about 55 mm. to 60 mm. in length; but other fragmentary remains show that the adult fish reached a larger size, probably about 90 mm., and this size corresponds with that given by Dr. Traquair.

The bones of the head appear to be of the same form and to have the same arrangement as those of other members of the genus *Rhadinichthys*. The cranial buckler, as shown by specimens in my collection and as pointed out by Dr. Traquair, is ornamented with "tolerably coarse ridges, passing here and there into tubercles." The opercular bones are ornamented in a similar manner, but the ridges appear to be somewhat finer, not so frequently interrupted, and rather more irregular in arrangement. On the maxillæ the ridges are moderately coarse, are interrupted at distant intervals, and recur in slightly wavy lines more or less parallel with the inferior border, which does not show any signs of tuberculation. The mandible, as pointed out by Dr. Traquair, is "slender and tapering, sculptured with a few tolerably coarse ridges, which, as usual, pass forwards and also obliquely upwards to meet the dentary margin at a very oblique angle." The teeth are small, conical, and somewhat incurved.

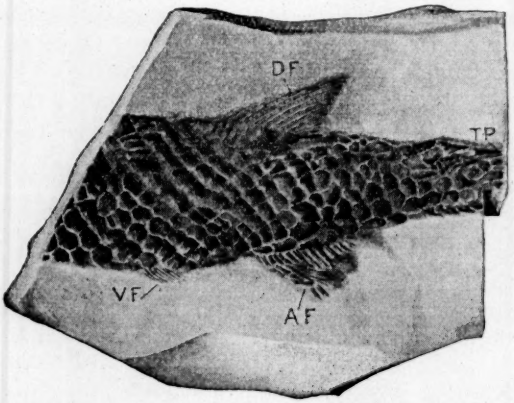
The bones of the shoulder-girdle are of the usual form and arrangement, and are sculptured with ridges which are interrupted at distant and irregular intervals, and which run more or less parallel with the borders of the bones.

The body is elegantly fusiform, but somewhat elongated, the greatest depth being at a point about midway between the occiput and the commencement of the dorsal fin, the depth here in one specimen in my collection being 10 mm. and the total length of the fish (when perfect) probably about 50 mm. From this deepest region the body gradually tapers to a delicate tail pedicle.

The scales on the nape appear equilateral; on the mid-flank they are slightly higher than broad; on the belly they become low and narrow; and posteriorly they get gradually smaller and more nearly equilateral until on the tail pedicle they assume the usual lozenge-shaped form. The scale ornamentation consists of (1) a few sharply cut, faint striæ, which run parallel and close to the anterior and

inferior borders, and (2) four or five ridges which commence at the posterior denticulations and run forward for some distance across the scale, the ridges becoming somewhat more oblique from below upwards. This sculpture is most strongly marked on the scales of the nape, but from this point it gradually appears to become fainter, the striæ parallel with the anterior and inferior borders being first lost; the ridges then become fainter and less marked, but the posterior denticles, although they become less in number, appear to be present on the scales far back on the body near the tail pedicle.

The pectoral fin, as pointed out by Dr. Traquair, appears to have been "of moderate size and its principal rays unarticulated until near their termination." The ventral fins are not well shown in any specimen, but one in my collection shows a trace of one of these fins, though not in a condition to permit of a detailed description: it appears to have been small and delicate. The dorsal fin is beautifully shown in the specimen mentioned above: it commences at a point very slightly in advance of the anal fin, the two fins being nearly opposed to each other. This fin is of moderate size, acuminated, concavely cut out behind, and composed of delicate rays which dichotomize distally, the terminal branches of the rays being very fine. The rays are distantly articulated, and show a single, sharply cut, longitudinal furrow. The anal fin in the same specimen is more imperfect, but a fin of similar form and construction is indicated. The caudal fin in the above specimen commences at a point about 17 mm. behind the commencement of the dorsal fin, but unfortunately only the proximal portion of the fin is shown. According to Dr. Traquair, the "rays are delicate and their articulations rather distant."



Rhadinichthys monensis, Egerton. Twice natural size.
DF, dorsal fin; AF, anal fin; VF, ventral fin; TP, tail pedicle.

In the Yorkshire Coal-measures this fish is mostly found in a very fragmentary condition; but it has a wide distribution, and occurs in the shale above the following coal-seams:—

I. Lower Coal-measures.
- *a.* Halifax Soft-bed Coal (Shibden).
- *b.* Halifax Hard-bed Coal (Queensbury).
- *c.* Better-bed Coal (Low Moor and Wyke).
- *d.* Black-bed Coal (Low Moor).
- *e.* Cannel Coal (Whitehall Lane, near Low Moor).
- *f.* Crow Coal (near Leeds).

II. Middle Coal-measures.
- *a.* Cannel Coal (Tingley).
- *b.* Haigh Moor Coal (Castleford).
- *c.* Barnsley Thick Coal (Barnsley).

In different individuals the scale sculpture shows very considerable differences as regards the strength and prominence of the scale-markings, the sculpture being much more pronounced in the case of some individuals than in others where the scales seem almost smooth. Another point of interest is that in the young fish the ventral scales do not appear to be so low and narrow as they are in the more adult fish. The fish, a young one, which has been carefully figured above, shows this well.

VII.—Note on a Tortoise from the Wealden of the Isle of Wight.

By Reginald W. Hooley, Esq.

In May, 1897, a fossil tortoise was found about 10 feet above low water-mark opposite Shepherd's Chine, by Mr. Wm. White, of Atherfield, Isle of Wight. It came into my possession in July of last year (1899). At that time the only portions clear of matrix were the sixth, seventh, and eighth costal bones, the edges of the marginals, and the epi- and hyoplastrals nearly to the notch; the matrix is a fine silt containing much iron. The specimen had been subjected to long attrition by the sea. A very thin but hard seam of whole and broken *Paludina* had offered a stubborn resistance, as likewise it did against a finely pointed and tempered chisel. On the surface of the carapace are several Cyprids (sp.?) and the impression in section of *Paludina*.

The carapace is somewhat distorted and flattened; in its present state it measures $12\frac{1}{2}$ inches long from *A* to *B* and $14\frac{3}{4}$ inches wide from *C* to *D*; in life its shape was probably ovoid. A semicircular piece of the fifth costal on the left side and the greater portion of the posterior costals, the pygals, and posterior marginals have been destroyed by the sea subsequent to the fall of the specimen from the cliff, but in other respects it is remarkably complete.

The neurals, eight in number, are narrow and elongate, some being twice as long as broad. There are eight costals, of which the second, third, and fourth have been depressed beneath the rest of the carapace to the extent of their thickness, and outer ends of the first and fifth left costals, moreover, have been forced under the marginals. The nuchal is emarginate and seems to be divided; there are eight marginals on the right, with a portion of the seventh and eighth wanting, and seven on the left, with but part of the seventh remaining.

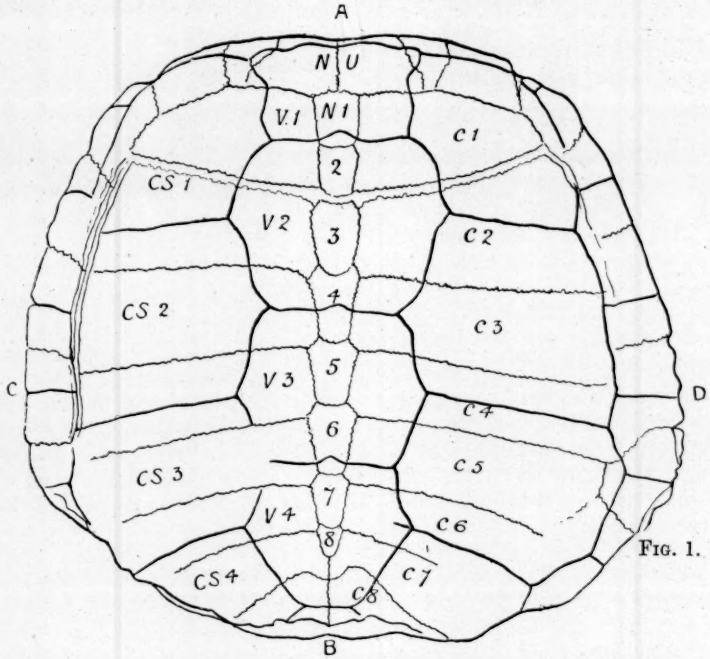


FIG. 1.

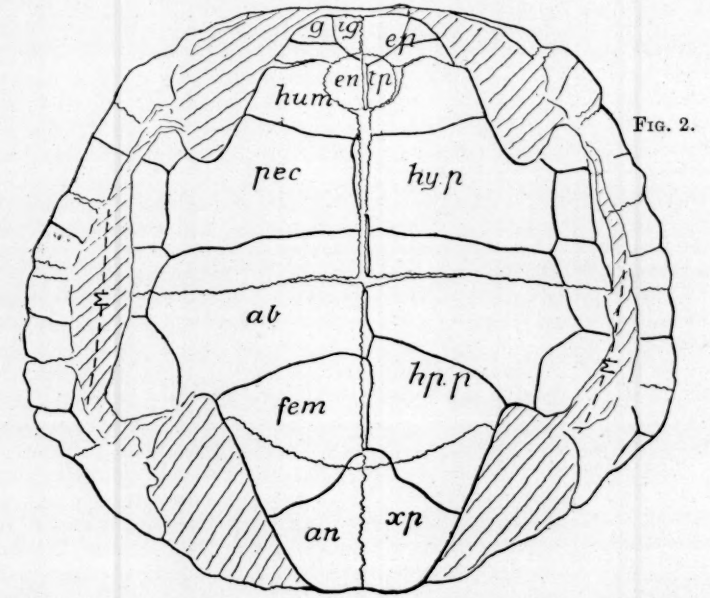


FIG. 2.

PLESIOCHELYS VECTENSIS, sp. nov. Drawn one-fourth nat. size. (For explanation, see p. 265.)

The vertebral shields are wider than long, the first by $1\frac{3}{4}$ inches, the second and third by 1 inch, the fourth by $\frac{1}{2}$ inch. The area underlying the second and third vertebral shields is slightly fluted, that under the others is smooth.

The entoplastral is wide, and rounded anteriorly and posteriorly; mesoplastrals are absent. The suture between the hypo- and the xiphiplastrals commences below the apex of the sulcus dividing the anal and femoral shields, thence it ascends and terminates nearly at the top of the inguinal notch. The sulcus dividing the abdominal and femoral shields is entirely on the hypoplastrals; it ascends towards the hyoplastrals, and terminates in the inguinal notch. The anal shields extend on to the hypoplastrals. The total length of the plastron is $12\frac{1}{4}$ inches.

From the above particulars I conclude that the specimen belongs to the genus *Plesiochelys* (Rütimeyer). It differs from *P. valdensis* by the very slight fluting of the area underlying the vertebral shields; indeed, as mentioned, this is absent except under the second and third. It can be distinguished also by the fact that the vertebral shields extend only one-third across the costal bones; in this respect it agrees with *P. Brodiei*. The shape of the shields differs from that seen either in *P. Brodiei* or *P. valdensis*, and approaches very nearly to the form characteristic of *Pleurosternum concinnum*. The shape of the nuchal bone is different from that of the other species mentioned, and the entoplastral, instead of being V-shaped posteriorly, is rounded. The suture of the xiphiplastral bone in *P. Brodiei* is very nearly horizontal, whilst in the specimen now described it ascends and terminates a little below the inguinal notch.

I endeavoured by the matrix, the *Paludina* seam, and Cyprids on the surface of the carapace to fix the exact horizon whence the specimen came, but after diligent and careful search could not locate closer than it is within the 49 feet of Wealden shales immediately overlying the sandstone of Cowlease Chine and Barnes High, therefore about 120 feet more or less below the Perna Bed; but if the Cyprids on the carapace prove to be *Candona Mantelli* (Jones) this would, I think, be sufficient to fix the horizon at 100 feet below the Perna Bed in the 9 feet of shales with *Candona Mantelli* (Jones) in the section on p. 15, Memoirs of Geological Survey, Isle of Wight, 1889.

My amateur examination seems to point to this being a new species; if it be so I would suggest *Plesiochelys vectensis* as its name.

EXPLANATION OF PAGE-PLATE ILLUSTRATION (p. 264 opposite).

FIG. 1, A.—The carapace (dorsal aspect).

FIG. 2, B.—The plastron (ventral aspect).

ab. Abdominal shields.
an. Anal shields.
c 1–8. Costal plates.
cs 1–4. Costal scutes.
entp. Entoplastral plate.
ep. Epiplastral plate.
fem. Femoral shield.
g. Gular shield.
hum. Humeral shield.
hpp. Hypoplastral plate.
hyp. Hyoplastral plate.
ig. Intergular plate.
n 1–8. Neural plates.
nu. Nuchal plate.
xp. Xiphiplastral plate.
v 1–4. Vertebral shields.

M = matrix.

VIII.—The Stability of the Land around Hudson Bay.

By J. B. Tyrrell, F.G.S.

In a former number of this Magazine, and also in a Report published by the Geological Survey of Canada, I showed reasons for believing that while the land around Hudson Bay, in the northern part of Canada, had undoubtedly risen several hundred feet in Post-Glacial times, it has now reached a condition of stability similar to that of the land along the Gulf of St. Lawrence and on the eastern seaboard of Canada.

In taking this position I was obliged to combat the views of my friend, Dr. Robert Bell, of the Geological Survey of Canada, who had stated, and who has since repeated the statement before the Geological Society of America, that the land around Hudson Bay is now rising at the rate of from seven to ten feet in a century.

Some valuable historical light has just been thrown on this interesting question by the publication of Jens Munck's account of his expedition to Hudson Bay in 1619 A.D., translated from the Danish and edited by C. C. A. Gosch, and published by the Hakluyt Society in 1897.

Jens Munck entered Hudson Bay eight years after it had been discovered by Henry Hudson, and as far as is known he was the first white man to enter Churchill harbour, on the west side of that great Bay, or inland sea. Here he spent more than ten months, from the 7th September, 1619, to the 16th of July, 1620; but as his account of his expedition was written and published in Danish, and has not previously been translated into English, it has remained almost entirely unknown.

His sailing directions for entering the harbour are as follows:—"Whoever desires to enter the harbour must leave the beacons (on the rocks to the west) to starboard and sail in, steering south-west. A little way inside the entrance there is a sunken rock under the water, but on the eastern side, so that one can pass it without difficulty. One may then cast anchor in 7 or 8 fathoms."

These directions were written nearly three hundred years ago, and they describe the conditions exactly as they exist at present. The sunken rock is still in the eastern side of the channel, so that ships must keep along the western side. As that rock, in 1619, was a menace to navigators, it could not have been more than a few feet under water, and if the land had since then been rising at any such rate as from 7 to 10 feet in a century, it would now be high out of the water. A difference in the relative elevation of land and water of even a few feet would have made a great difference in the character of this channel, but instead it seems to have been the same then as now. There can be no doubt as to the rock meant by Munck, for there is only one conspicuously in the channel, and the banks are otherwise very regular.

After entering the outer channel the depths of 7 or 8 fathoms in the harbour are almost precisely the same as those shown on the chart made by the officers of the Canadian Government in 1886, namely 6 to 8¼ fathoms.

Furthermore, in this book several plates are inserted, one of which, opposite p. 23, shows Churchill harbour, and Munck's ships moored near its western side, one Danish mile (= 4½ English statute miles) from its entrance. The ships lay on the tidal flat, which was "nearly 900 fathoms across," and were "not farther from the shore than about 12 or 14 fathoms." They evidently lay a short distance above a high point extending down to the shore of the harbour from the west, and their position was therefore somewhere in front of where the Hudson's Bay Company's Trading Port is at present situated.

The plate represents a bird's-eye view of the harbour, and shows it very much as it would appear in a similar view at the present time, and not at all as it would appear if the land had been rising since then at any such rate as from 7 to 10 feet in a century, or say in all 19–25 feet, for much of the surrounding land is so low that with such a difference in elevation large areas, which are now dry land, would have then been submerged.

Mosquito Point, a low rocky point at the head of the harbour, is distinctly shown on the plate, and Fort Prince of Wales or Esquimaux Point, which projects beyond the mouth of the harbour on its western side, is clearly seen to be connected with the more southern portion of the mainland, as it is now, and there is no sign of a channel across the connecting neck of land, though the land is there so low that a depression of a few feet below its present level would cause the existence of a wide and distinct channel here. Had this channel existed in Munck's time there can be little doubt that it would have been shown on his map.

As these are the oldest historical records obtainable of the former character of Churchill harbour they are of considerable geological interest, and they are clearly in line with the arguments which I adduced in a former paper in this Magazine, that during the historical period there has been no determinable change in the relative levels of land and water on this portion of the western shore of Hudson Bay.

IX.—Firstfruits of a Geological Examination of Snowdon.

By J. R. Dakyns, Esq.

Ars longa, vita brevis. This is especially true when one reaches the age of 64. I therefore commit to paper some of the results of a geological investigation of Snowdon on which I am engaged. I start of course from the work of Messrs. Ramsay and Selwyn embodied in the Geological Survey Map of Snowdon and Ramsay's memoir on North Wales. To make what I have to say clear I may state that the rocks of Snowdon are by Ramsay and Selwyn divided into three principal groups, viz.: A, an upper felsitic lava; an intermediate band (B) of bedded fossiliferous rocks of Bala age, containing much volcanic material, called the calcareo-felspathic ashy series; and a lower mass (C) of felsitic rocks. This lower mass is in some places divided by sedimentary bands consisting of slates and grits. Below C come blue slates and grits, with

occasional volcanic bands, D; and below D the great mass of volcanic rocks (E) which form Glyder Fach and Y Tryfan.

1. The lower Snowdonian felstones (C) are coloured on the map as lavas, and are always spoken of as such in the memoir on North Wales. In many places, however, they are not lavas, but fragmentary rocks. Their fragmentary character may be seen (to mention a few localities) in Cwm Llan, especially west of the copper vein not far from the stone erected in honour of Gladstone, and also near the footpath leading from Rhyd-dhu to Snowdon some five hundred yards or so beyond the half-way house. These rocks, C, in fact, consist of three kinds:—First, massive uncleaved rocks showing fluxion structure and in some places columnar; these are undoubtedly lavas: secondly, compact, often close-jointed, rocks of a smooth fracture, somewhat like lava, but without fluxion structure; these are probably tuffs or masses of consolidated felsitic dust: thirdly, highly cleaved felsitic rocks. These last are in some places obviously of a fragmentary character, but more often not so; and in such cases it is difficult to say whether they are so-called volcanic ash or cleaved lavas. As the obviously fragmentary rocks are part and parcel of them, my own opinion is that they consist mainly of ash; but to settle this question definitely microscopic examination is needed. A slice cut from one of these fine and highly cleaved felsitic rocks shows (as Mr. Greenly tells me) certain small aggregates with igneous structure, which look much more like fragments than surviving augen from such rocks as the Bala felstones. The rock also contains a considerable quantity of calcite, much more than could be expected from the felsitic lavas in question, none of which have yielded so much as ·5 per cent. of lime (Harker, "Bala Volcanic Series," p. 13). It is probable, therefore, that the rock is a felsitic tuff or dust.

2. Ramsay has pointed out on p. 150 of "The Geology of North Wales" how difficult it is to fix on a boundary-line between these lower felsites and the overlying series (B) on the ridge of Llechog, west of the peak of Snowdon, because both are felspathic and both cleaved. In my opinion the difficulty is due to the fact that both are ashes; but I have not yet had any specimen from this locality sliced and examined. In many places, the lower rocks look to me like the 'altered ashes' of the Lake Country.

3. Not only are the lower felsites often intensely cleaved, but a very striking peculiarity about them in many places is their sheared appearance; they are often more than cleaved, they are sheared (or even to a slight extent foliated[1]), so much so as in some places to remind me of the quartz-schist of the Western Highlands. This quasi-foliated appearance is (among other places) remarkable alongside the road from Rhyd-ddu to Beddgelert.

4. The great mass of these rocks (C) is quite devoid of bedding. In fact, their unbedded character is the chief distinction between them and the overlying series. At the same time, it is not always easy to fix upon a good line of demarcation between the two, as

[1] The divisional planes are coated with thin sheets of 'sericitic' mica.

the lower rocks are bedded near the top; or perhaps one should say it is in places convenient to include some well-bedded rocks with the lower group for the sake of carrying on a line. In some places, however, lines of bedding are to be seen in the heart of the group (C). This is the case just above Glaslyn, on the north side of the tarn, where the rocks are of an ashy nature, and are dipping at 60° to the W.S.W. near a fault.

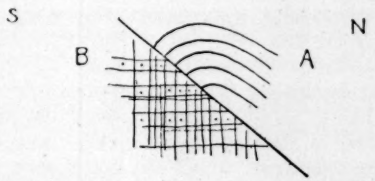
5. Immediately south of the outflow of Llydaw there are some curious greenish rocks of a fragmentary character, in which, however, one can rarely find any distinct bedding. They occur apparently at the base of the calcareous series (B), though very unlike the basement beds of that series seen hard by, and seem to wrap round the upper part of C, partly owing to a roll over, but chiefly from their having, as it seems to me, been deposited against and around a boss of the lower felsitic rocks. They include one or two bosses of an intrusive rock also of a greenish hue, which are probably connected with the great mass of diabase that forms Clogwyn Aderyn and Clogwyn Pen-llechen.

6. I may state, as I have not seen it mentioned anywhere, that the beds B are often beautifully false-bedded, or, as I prefer to say, cross-bedded. This is well seen in Cwm Glas.

7. In the same Cwm the base of the upper felstone (A) is plainly to be seen running down northward from the ridge of Crib-y-ddysgl to the northern end of Clogwyn Person; and it is here manifest that the felstone lies in a hollow in the underlying beds (B), for it is in contact with higher beds of B on the ridge than at the north end of Clogwyn Person, where the junction of the two rocks is clearly seen to be a natural and not a faulted one.

8. On Crib Goch the upper felstone consists entirely of a mass of blue close-grained columnar felstone showing lines of viscous flow. On Crib-y-ddysgl the rock consists of two distinct parts, separated by a thin band of slate or cleaved tuff. The lower part is a massive, but not always columnar, felspathic rock, containing on the ridge calcareous seams interbedded with it near its base. This is succeeded by a thin seam of cleaved tuff, inconstant in occurrence, overlaid by a columnar felstone exactly like the rock of Crib Goch.

The section at the base, seen on the Cwm Glas side of the ridge, is very interesting. The interbedded calcareous seams are bent over thus:—



as if (after consolidation) the rock had been thrust from north to south over the underlying slates and ashes, against which its layers had dragged at the junction. I have not yet traced the outcrop of

the thrust plane, but it cannot coincide throughout with the junction of A and B, because, as stated above, that junction is at Clogwyn Person a natural one.

In the figure, which is merely a diagram, the curved lines in A represent calcareous seams in the felstone; and in B the gently sloping lines represent bedding, and the vertical lines cleavage.

9. I had long years ago noticed some peculiar vesicular rocks in the calcareo-ashy series, which puzzled me. It was Sir Archibald Geikie who first pointed out that there were andesites on Snowdon. After reading his account of these, I examined the rocks in the places on Snowdon mentioned by him, and then found that these andesites were one and the same with my peculiar vesicular rocks, so I set about mapping them, and very useful I have found them in showing where faults do and do not occur. In doing this work I have found and partly mapped several rocks that bear a family likeness to one another; some of them are not vesicular, and I fancy may be fine-grained andesitic tuffs; but whether tuffs or lavas, they form a group of similar rocks distinct from the rocks amid which they occur. They are characterized by a splintery fracture, smooth texture, dull grey colour, rusty weathering, and are often highly cleaved. Most of the specimens examined show under the hand lens the characteristic "trachytic meshwork of minute felspar laths." At present I look upon them as contemporaneous interbedded rocks: there are, however, places where they might be supposed to be intrusive, but perhaps this is a deceptive appearance due to faulting. I do not know yet about this.

The regions where I have mapped, or commenced mapping, them are on the flanks of Crib-y-ddysgl and beneath the peak of Snowdon, both above Glaslyn on one side and at the head of Cwm Clogwyn on the other, and on the ridge leading from the summit of the mountain to Bwlch-y-maen. I suspect from what I have lately seen (in unfavourable weather) that similar rocks also occur, as is but natural they should, in the calcareous series south-east of Lliwedd, and I know that a rock of this description forms Clogwyn-y-gysgfa on the east side of the road from Pen-y-gwryd to Beddgelert.

The andesitic rocks lie chiefly in the calcareous series (B), but one, a well-marked lava, which I had mapped as such before I knew anything about andesites, occurs amid the lower felsitic rocks (C) near the head of the rocky spur called the Gribbin or Criman, which runs down to the foot of Glaslyn from the south. I see that the tracing of these beds will necessitate a modification of some of the lines on the Survey map.

10. As far as I know, all the intrusive rocks coloured as Greenstones on the Geological Survey map are Diabases; but there are others of a different character, which are not shown on the Survey map, to wit, a boss of igneous rock of an apparently intermediate but variable character (as I am informed by Mr. E. Greenly) on the south side of Cwm Dyli, a mass of Diorite below Caer-gors (rather more than a mile from Rhyd-dhu station), and several sills and

dykes of an intermediate character on Mynydd Drws-y-coed. I may as well say at once that the mineralogical character of all the above-mentioned rocks, as well as of others not mentioned, were determined[1] for me by my friend Mr. E. Greenly, to whose great kindness in naming my specimens my warmest thanks are due.

There are also some intrusive felstones, bosses, and dykes in the Snowdon area. One of these I have already mentioned in a note to the British Association at Bristol. It is an oblong mass of felstone, showing lines of viscous flow parallel to its north-western face, and rudely columnar perpendicular to that face, exactly like the felstone of Crib Goch, and not like any part of the lower felsitic rocks of the immediate neighbourhood. I take it to be a plug and root of the Crib Goch lava. It occurs between Glaslyn and Bwlch Goch.

On the ridge called Llechog, that bounds Cwm Clogwyn on the south, a band of compact uncleaved felstone, running N.W. and S.E., stands up as a dyke amid the cleaved felsitic rocks (C). In the Cwm also a felstone dyke running W.N.W. and E.S.E. is seen rising up the cliff. This may possibly be the lower part of the dyke mentioned above. I have not decided about this yet.

I may remark that the existence of felstone dykes amid the Snowdonian rocks is a discovery, for none such have been hitherto recognized.

11. The great masses of diabase that occur so plentifully in the neighbourhood of Snowdon are generally massive rocks quite uncleaved, but they are often cleaved or sheared along their margins. Ramsay remarks on this feature, and says, on p. 157 of "The Geology of North Wales": "At its junction with the felspathic porphyry the greenstone is often partially decomposed; its crystalline character is gone (probably from rapid cooling at its sides), and it possesses a flaky structure to so great an extent that it sometimes looks like some of the cleaved dark-green calcareous ashes, or in other cases assumes an appearance of a more slaty description." This is an excellent description of the diabase along its margin, but there is evidently some confusion between the phenomenon of a chilled edge and that of marginal cleavage or schistosity, which must (as it seems to me) be due to movement or pressure. The same sort of thing occurs in the Scottish Highlands, where masses of basic rock among the schists are sheared along their margins, though in the Highlands the rock is generally reconstructed. Besides the above-noted deformation along their margins, the diabases are in some localities deformed and rendered schistose, or something very like it, throughout nearly their whole extent. I first noticed this in Cwm Llan, on the south side of Snowdon, and took Mr. Greenly to see it, so different in appearance was the rock from that of the ordinary run of diabases. A precisely similar rock occurs on the west side of Snowdon near Llyn Nadroedd. On the Geological Survey map a large mass of greenstone is represented there, but it really consists of two separate masses

[1] Only a few, however, have yet been sliced.

of intrusive rock parted by a band of felsite about seventy yards wide. The upper of these is a massive unsheared diabase of the ordinary type. The lower is exactly like the Cwm Llan rock, with which it is doubtless connected underground. Both of these masses (viz., the Cwm Llan rock and the lower of the basic rocks near Llyn Nadroedd) are highly complex, including a considerable variety of material, of the mutual relations of which, as well as of their relation to the surrounding rocks, I hope to be able some day to give a detailed account.[1] The bulk of the rock is a dark-green schist, with a highly developed parallel structure and a fine silky lustre on the foliation planes. Under the microscope the rock is seen to be completely reconstructed and recrystallized, to be a finely felted or schistose aggregate, in fact, a perfect crystalline schist. Chlorite, indeed, forms the bulk of the rock, with granules of epidote, magnetite, and leucoxene; but some specimens are largely composed of minute needles with a much higher double refraction than chlorite, which can hardly be anything but a pale-green hornblende, produced apparently at the expense of the chlorite, and the result therefore of a more advanced stage of metamorphism. A curious feature is the presence in some of these schists of a large number of small concretions (up to the size of large peas). These are composed of a quartz mosaic, with generally a border of radially arranged needles of a green mineral, chiefly chlorite, though hornblende is also present. Some are perfect little radial spherulites. Many of these concretions can be seen to cut sharply across the foliations, and no sign of strain has been observed in their minerals, so that it is clear that they are not amygdules, but that they have grown since the last deforming stresses to which the rock was subjected.

The character of these rocks is so different from that of any other of the Snowdonian rocks that the thought crossed my mind whether they might not be a boss of Archæan rocks sticking up in the valley bottom; but this idea, to say nothing of the structural difficulties, was negatived by finding that the metamorphic rock enveloped masses of grit, and was therefore intrusive.

12. Before closing this summary of my work, I may as well mention that there is a mass of basic intrusive rock, not shown on the Geological Survey Map, amid the rocks of the calcareous series S. by E. from Cwm Dyli waterfall and nearly opposite Gwastad Agnes, which I have not yet mapped; and that I have found and mapped a boss of diabase of the Siabod type, not shown on the Survey Map, from 450 to 700 yards N.N.W. of Pen-y-gwryd.

I find, too, that the upper part of the felstones of Glyder Fach on the southern slope of the hill consist of breccias which pass up gradually into grits.

13. In conclusion I will briefly state the chief things discovered by me in the Snowdon area: these are, first, the fact that much of

[1] The following mineralogical description has been communicated to me by Mr. E. Greenly.

the lower felsitic rock spoken of as lava is really of a fragmentary character; secondly, the existence of dykes and intrusive masses of felstone; and thirdly, the highly metamorphic rocks of Cwm Llan and Llyd Nadroedd. These three things are all new. Fourthly, the occurrence of diorite in the Snowdon area is a discovery.

X.—Diagram of Composition of Igneous Rocks.

By H. Warth, Esq.

RECENT studies about the average chemical composition of larger numbers of igneous rocks in the aggregate have shown that figures obtained from any one hundred or more samples are very similar, in fact practically equal. (See A. Harker, "On the Average Composition of British Igneous Rocks": Geol. Mag., No. V, May, 1899.) This will be found also the case when comparing the following average which I calculated from the analysis of igneous rocks compiled by Roth in his "Petrographie der plutonischen Gesteine."

Now if it is of interest to discuss these average results, notwithstanding the wide discrepancies of many individual compositions, it may also be worth while to find out how on the average the compositions vary with the relative acidity of the rocks. For this purpose I have arranged the bulk of Roth's samples in the order

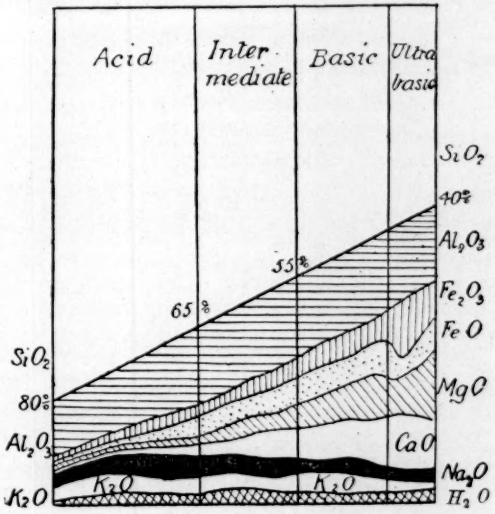


Diagram-Fig. 1.

of acidity, and after calculating average compositions of eighteen groups of closely approaching acidity, I constructed from the figures the subjoined diagrams. The first diagram (Fig. 1) shows the actual results, the second (Fig. 2) shows them rounded off.

The percentage of silica varies from 80 to 40, and the usual limits between acid, intermediate, and basic rocks are indicated by the vertical lines on the diagrams. The diagrams show the percentage of the different bases which corresponds with the percentage of silica indicated on the straight diagonal boundary-lines of the silica which rise from the points marked 80 per cent. on the left of

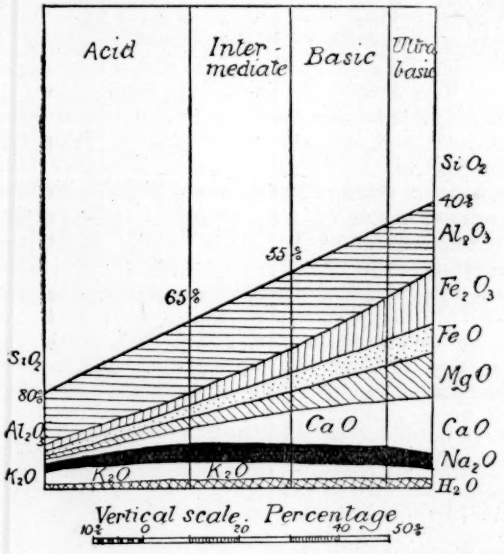


DIAGRAM-FIG. 2.

each diagram to the points marked 40 per cent. on the right of each diagram. As it would not be possible to give so many details on the diagram, small quantities of other acids have been reckoned with the silica and treated as such. These acids are titanic acid, phosphoric, carbonic, and in rare cases also sulphuric acid. In the case of the bases I also included the manganous oxide, and a few other rarer metallic oxides with the ferrous oxide. The total number of specimens which were calculated amounted to 428. About sixty-six of Roth's analyses were omitted, partly because they referred to strongly weathered specimens, and partly to exclude serpentines and some other more purely magnesian silicates. The specimens as given by Roth are from generally distributed localities, and the following are the compositions of extremes and of the total average in numerical figures:—

	$\ddot{Si}$	$\dddot{Al}$	$\dddot{\underline{Fe}}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{Ca}$	$\dot{Na}_2$	$\dot{K}_2$	$\dot{H}_2$
Most acid... ...	79·7	11·4	1·1	0·3	0·7	0·9	2·6	2·5	0·8
Most basic ...	40·0	12·3	10·2	5·8	14·2	10·5	3·1	1·2	2·3
Average	58·3	15·3	5·0	3·6	4·0	5·9	3·4	3·0	1·5

The diagrams show the alumina to be nearly constant, only slightly diminishing towards both extremes. The soda is also tolerably constant, diminishing slightly at both ends. The potash is decidedly stronger at the acid end, whilst the other oxides increase from left to right so as to show quite a fan-like expansion from the acid end towards the basic end.

The diagrams show also that the arbitrary boundaries between acid, intermediate, and basic rocks are very suitably chosen.

REVIEWS.

Bollettino della Società Sismologica Italiana, Vol. V (1899–1900).

EXCLUDING two bibliographical notices, the present volume contains nineteen papers, of which all are interesting and one is important. In addition, is the catalogue of earthquakes recorded in Italy during the year 1898, compiled by Dr. G. Agamennone and his successor Dr. Cancani. The value of this work is abiding, and increases with every fresh year of its existence.

If we may judge from this volume, the recent energies of Italian seismologists have been directed less to the invention of new instruments and more to the study of their records. Nevertheless, Drs. Vicentini and Pacher have made an important addition in the form of a vertical component microseismograph. The paper in which it is described, and the representations of some of its records, are most interesting. Dr. G. Agamennone has devised a new seismoscopic clock, and Dr. G. Pericle one more seismoscope.

Professor A. Riccò, of Catania, gives a summary of a report on the destructive earthquake of November 16, 1894, in Calabria and Sicily, and on its relations with the earthquakes of 1783. From the same writer we have also an account of the Etnean earthquake of May 14, 1898. Dr. Agamennone describes the Balikesri (Asia Minor) earthquake of September 14, 1896, the Apennines earthquake of March 4, 1898, and the Modena-Bologna earthquake of February 2, 1900; while Dr. Cancani studies the Latian earthquake of July 19, 1899. In connection with barisâl guns Professor Issel's supplementary paper on the Umbria Marches earthquake of December 18, 1897, is deserving of study.

Professor Mercalli contributes observations on Vesuvius (July–December, 1898), and Mr. R. V. Matteucci others on the Italian volcanoes generally. On July 19 and 25, 1899, violent explosions occurred in the central crater of Etna; these are carefully described by Mr. S. Arcidiacono, and their effects on the condition of the crater by Mr. A. Mascari.

C. Davison.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 21, 1900.—H. W. Monckton, Esq., F.L.S., Vice-President, in the Chair. The following communications were read:—

1. "On a Bird from the Stonesfield Slate." By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

During his residence at Oxford the late Earl of Enniskillen made a collection of Ornithosaurian bones from Stonesfield, which was acquired by the British Museum in 1866. Among these is one identified by the author in 1899 as the right humerus of a bird about as large as a flamingo. The bone is complete, except for fracture through the proximal articulation, and the specimen is on the whole well preserved. The chief characters available for comparison are the form of the shaft, the character of the proximal end, especially the ulnar tuberosity and the radial crest, and the form of the distal end. The character which first showed the fossil to be a bird was the ulnar tuberosity; probably the flamingo approaches as closely as any living genus to the Stonesfield fossil in this feature. The radial crest shows affinities with those of the flamingo and the eider-duck. The impression left by the humero-cubital muscle on the external surface above the condyles is almost identical with that seen in the flamingo. "The varied affinities of this large Carinate bird appear to lie midway between the ducks and geese on the one side, and the herons and flamingos on the other. It may be placed in a new family; but its characters are in all respects such as might have occurred in an existing bird. There is no indication of affinity to the *Archæopteryx*, or that the bird diverged in any way from modern types."

2. "The Lower Ludlow Formation and its Graptolite-Fauna." By Miss Ethel M. R. Wood. (Communicated by Prof. C. Lapworth, LL.D., F.R.S., F.G.S.)

After dealing with the literature of the stratigraphical and palæontological sides of the subject, the author passes to a full consideration of the sequence and character of the Ludlow Rocks in the following localities: the Ludlow district, the Builth district, the Long Mountain; and gives a briefer account of those of the Dee Valley, the Lake District, Southern Scotland, Dudley, and the Abberley Hills. While the Wenlock Shales are characterized by *Cyrtograptus* and by the *Flemingii*-type of *Monograptus*, in the Lower Ludlow Shales the *colonus*- and spinose forms of *Monograptus* such as *M. chimæra* are abundant. The line between Lower and Upper Ludlow is drawn at the top of the Aymestry Limestone. The Lower Ludlow Rocks are divided into five graptolitic zones, which are not constant in character or thickness in the different areas. The distribution of the zones is given in the annexed table (p. 277). Two of the zone-graptolites are new species, described in the latter part of the paper.

TABLE ILLUSTRATING THE DISTRIBUTION OF THE GRAPTOLITE-ZONES.

Zones.	Ludlow District.	Builth District.		Long Mountain District.	Dee Valley.	Lake District.
		Eastern Area.	South-Western Area.			
Zone of *M. Leintwardinensis*	Aymestry Limestone (275 feet). Calcareous laminated flags, passing down into light-brown flaggy mudstones (210 feet).	Thin calcareous bands and micaceous laminated flags, passing gradually into	Dark micaceous and calcareous flags, well laminated, passing gradually into	Micaceous flags, passing into	'*Leintwardinensis*-Flags.'	Bannisdale Slates. [Upper parts calcareous.] (5,000 feet.)
Zone of *M.* sp. nov.	Light flaggy mudstones (220 feet).	Light flaggy mudstones and darker calcareous flags (400 to 500 feet).	Light flaggy mudstones.	Light flaggy mudstones. (900 feet ?)	Upper Gritty Beds. [No fossils.]	Coniston Grits.
Zone of *M. scanicus.*	Light flaggy mudstones and shales (100 feet).	Greyish-brown shales, with some flaggy mudstones (250 feet).	Unknown.	Greyish-brown thinly-bedded shales (350 feet).	Nantglyn Flags.	Upper Coldwell Flags.
Zone of *M. Nilssoni.*	More thinly bedded mudstones and shales (120 feet).	Greyish-brown shales, with thin calcareous bands.	Greyish-brown shales, with thin calcareous bands (550 feet).			5,000 feet.
Zone of *M.* sp. nov.	Thinly bedded shales. No graptolites. (130 feet.)	Dark-grey calcareous shaly flags. 300 feet.	Dark-grey calcareous flags, with conchoidal fracture (100 feet).	Dark-grey calcareous flaggy shales (600 to 700 feet ?).		Middle Coldwell (?).
	Wenlock Limestone.	Wenlock Shales. (Zone of *Cyrtograptus Lundgreni.*)	Wenlock Shales.	Wenlock Shales.	Moel Ferna Slates.	Lower Coldwell (?).

In the Ludlow area the two lowest zones are rich in graptolites, but shade into each other, and are therefore less clearly defined than the higher zones, which each contain practically only one species and are lithologically distinct. In the Builth area the variation in the zones in different parts may be due to the conditions of depth and current under which the graptolites have been deposited, or to the overlap of higher beds on lower, as has been shown to be the case with the Wenlock and old Red Sandstone rocks. In the Long Mountain syncline *M. scanicus* is practically absent, and the typical *M. Leintwardinensis* of the highest zone has not yet been found, although its place appears to be taken by a varietal form. Two new species of graptolites are almost confined to this district. The succession worked out in these districts is confirmed by that in the Dee valley and the Lake District, but the evidence at present obtained in the three other areas is only scanty.

The Lower Ludlow sediments become thicker, coarser, and more arenaceous when traced from the south and south-east to the north and north-west; but, in spite of this, there is a striking constancy in the lithological sequence of the sediments. Only two of the graptolitic zones, those of *M. Nilssoni* and *M. Leintwardinensis*, are present in all the districts. A table is given to show the distribution of the graptolites in Britain and Europe, and one showing the order of appearance of the graptolites of the formation.

The Lower Ludlow graptolites present, as a whole, the following peculiarities, and stand in marked contrast to those from the Wenlock Rocks in the fact that while the polypary is straight for the greater part of its length, it is distinctly curved inwards at the proximal extremity. The apertures of the thecæ are for the most part either spinose, or wholly devoid of ornamentation. The number of species is eighteen, with thirteen varieties, of which six species and nine varieties of *Monograptus* and one species of *Retiolites* are new, and are described and figured in the paper. All the species and varieties of *Monograptus* are arranged round type-species into six groups. The richest groups in species and varieties are those of *M. dubius* and *M. colonus*. Most of these groups link the Ludlow Series with Wenlock, and even the genus *Retiolites* is common to the two formations. Thus the supposed great palæontological break between the two series to a great extent disappears.

II.—April 4, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read :—

1. "Additional Notes on some Eruptive Rocks from New Zealand." By Frank Rutley, Esq., F.G.S.

The rocks described in this paper were, with a few exceptions, collected by Mr. James Park. A few of the specimens come from the area of the Hauraki Goldfields, but many of them were procured from other localities in the North Island, including several from Rotorua. The silica-percentages of several of the rocks have been determined by Mr. P. Holland.

The first part of the paper deals with twenty-three rock-specimens and slides from them. These consist of rhyolites and obsidians,

with rhyolitic and pumiceous breccias and tuffs, geyserites, and sinters. The rocks exhibit spherulitic and perlitic textures, fluxion, devitrification, and impregnation with silica. In one case the obsidian, after solidification, appears to have undergone the following changes:—(1) devitrification, with formation of spherulites; (2) increase in temperature sufficient to destroy the double refraction of spherulites and the earlier formed felspars; (3) the decomposition of parts of the spherulites, causing them to assume the characters of a cross-grained felsite. The rocks from Rotorua exhibit the effect of solfataric action resulting in the production of a high percentage of silica in the rock, and the development of hyalite and isotropic opal silica or geyserite. In some cases these rocks have had silica substituted for portions of the spherulites which have been dissolved, the fibrous structure being preserved in opal-silica, which, nevertheless, exhibits double refraction.

In conclusion, the author suggests a comparison of certain ancient rhyolites of Great Britain with those of New Zealand affected by solfataric action. As to the causes which may convert a glassy into a lithoidal rhyolite we still seem to lack information; it is possible that the action of steam may be instrumental in effecting such a change, but this is probably only an occasional agent, and the more general cause of such changes must be sought elsewhere.

2. "On the Discovery and Occurrence of Minerals containing Rare Elements." By Baron A. E. Nordenskiöld, F.M.G.S.

The first mineral referred to is scheelite, and the next cerite, which contains no less than four rare metals. The incandescent light produced when the latter mineral is fused with charcoal-powder was first observed by Cronstedt in 1751. The discovery of glucina, lithia, selenium, and yttria is next referred to. Minerals containing yttria and oxides related to it were, at one time, thought to be almost limited to certain pegmatite-veins running in a broad zone on both sides of the 60th parallel of latitude. Latterly, fluocerite, orthite, and gadolinite have been found in Dalecarlia; and among these minerals Benedicks discovered a silicate of yttrium containing 1·5 per cent. of nitrogen and helium. The author discovered kainosite, a silico-carbonate of yttrium and calcium, among minerals from Hitterö; and the same mineral was subsequently discovered in the flucan, fissures, and drusy cavities at the Nordmarken mines. The last-mentioned discovery and others related to it appear to suggest that the mode of formation of fissure-minerals is not so unlike that of the pegmatite-veins of the Primary rocks as is generally supposed.

Thorium, discovered by Berzelius in 1829, was originally obtained from the rich mineral locality of Langesund (called Brevig in mineralogical literature), but it has since been recorded from other localities, including Arendal and Finnish Lapland. It is now obtained from the monazite-sand of rivers in the Brazils and South Carolina. Thorite contains about ·5 per cent. of inactive gas, probably a mixture of nitrogen and helium; but the latter element was first obtained from the mineral cleveite, also containing thorium, discovered by the author in 1877. Other minerals bearing nitrogen,

argon, or helium are referred to; and under the head of minerals bearing tantalum, mention is made of Giesecke's discoveries in Greenland. Among these is fergusonite, one of the richest sources hitherto known for obtaining that mysterious gas, or mixture of gases, which on our planet seems to be almost exclusively confined to minerals containing rare earths. "The group of earths, as well as the group of gases, of which we are here speaking, might therefore be compared with certain genera among organic beings, whose species, having not yet fully differentiated, offer to the descriptive zoologist or botanist difficulties analogous to those with which chemists meet in endeavouring to separate the rare earths and rare gases."

III.—April 25, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

The President, having requested all present to rise from their seats, read the following resolution which had been passed unanimously by the Council: "That this Council desire to place on record their deep sense of the loss which both science and literature have sustained in the death of the Duke of Argyll, who was the oldest surviving past-President of the Geological Society;" and stated that on behalf of the Council he proposed to communicate a copy of the resolution to the Duchess of Argyll, coupled with an expression of respectful sympathy.

The following communications were read:—

1. "On a complete Skeleton of an Anomodont Reptile from the Bunter Sandstone of Reichen, near Basel, giving new Evidence of the Relation of the Anomodontia to the Monotremata." By Professor H. G. Seeley, F.R.S., F.L.S., V.P.G.S.

This skeleton was originally described by Wiedersheim under the name of *Labyrinthodon Rütimeyeri* in 1878. The bones are now differently interpreted:

The reputed humerus is the interclavicle.
" " scapula is the humerus.
" " supra-scapula is the left coracoid.
" " " " right scapula.
" " right and left clavicles are the ribs.
" " right and left coracoids are the pre-coracoid and coracoid of the right side.

Five digits are identified in place of four in 1878. These osteological identifications are inconsistent with reference of the type to the Labyrinthodontia, and it is accordingly described as a new genus, which is placed in association with *Procolophon* as a separate family in the tribe Procolophonia.

The author discusses various views which have been expressed with regard to the position of the Labyrinthodonts. He has already separated these animals from the Amphibia and combined them with the Ichthyosauria in a group of reptiles named Cordylomorpha, and he enumerates a series of characters which constitute so close a link between the two types "that it is not possible, in the absence of

evidence, to conceive of their being referred to different classes of animals."

"But if the order Labyrinthodontia is transferred to the Reptilia, it is then manifest that by including such genera as *Branchiosaurus* and *Archegosaurus*, in which gill-arches are found, it introduces into the Reptilia a character hitherto unknown, and commonly regarded as Amphibian. . . . If the osteology of an ordinal type is Reptilian, it cannot be placed in the Amphibia, because two or three genera, or the whole group, preserve gill-arches. . . . The Labyrinthodontia may or may not be a homogeneous sub-class or order, though the circumstance that many writers have separated its groups on different principles, and into a varying number of orders, is some evidence that it includes a wide range in character. . . . In no part of the skeleton is there a close correspondence between living Amphibia, which are probably unknown before the Tertiary period, and the extinct Labyrinthodontia, which are only known with certainty in the Carboniferous, Permian, and Triassic periods of time."

"If the sub-orders of Labyrinthodontia are sub-orders of Reptilia and not of Amphibia, the transition which *Pareiasaurus* exhibits from Labyrinthodonts to Mammals ceases to be an anomaly."

"The close resemblance of form of the bones in the several parts of the skeleton now described with Monotremata and Anomodontia makes the border-line between Reptiles and Mammals more difficult to define."

The fossil is identified as an Anomodont reptile, chiefly on the basis of resemblance to *Procolophon* and *Pareiasaurus*. It is shown not to be a mammal by the large parietal foramen, the composite structure of the lower jaw, and the presence of the pre-frontal bone. It differs from known Anomodonts in making a somewhat closer approximation to Monotreme mammals than has hitherto been evident, and this correspondence extends to successive segments of both the fore- and hind-limbs.

The teeth are in sockets placed obliquely, with conical crowns compressed to sharp lateral margins, and curved inward. The proportions of the vertebral column are those of *Echidna*, though the transverse processes are longer, as in *Pareiasaurus*. The ribs are like those of a Monotreme, though the sacral ribs are longer. The shoulder-girdle resembles that of *Procolophon*, and differs from typical Anomodonts in the constituent bones being unanchylosed, and in the pre-coracoid having a large anterior extension in advance of the scapula. The sternum appears to have been unossified, as in Crocodilia. The humerus is widely expanded at both extremities and twisted, but does not show the peculiar lateral curvature seen in Monotremes. The ulna gives no evidence of an olecranon-process; it is larger than the radius, and appears to articulate with the humerus. The pelvic bones are without acetabular or obturator perforations, are not anchylosed together, and the ilium is not expanded transversely. The hind-limb is no larger than the fore-limb. The femur is more slender than the similar bone in *Echidna*. The fibula is prolonged proximally beyond the stout tibia round

which it may rotate. The proximal row of the tarsus is one large bone, formed of the blended astragalus and os calcis.

In conclusion, the author argues that the points of structure are so few in which Monotreme mammals make a closer approximation to the higher mammals than is seen in this fossil and other Anomodontia, that the Monotreme resemblances to fossil reptiles become increased in importance. He believes that a group Theropsida might be made to include Monotremata and Anomodontia, the principal differences (other than those of the skull) being that Monotremes preserve the marsupial bones and the atlas vertebra. *Ornithorhynchus* shows pre-frontal and post-frontal bones, and has the malar arch formed as in Anomodonts and some other reptiles.

2. "On Longmyndian Inliers at Old Radnor and Huntley (Gloucestershire)." By Charles Callaway, M.A., D.Sc., F.G.S.

The grits, with some associated slaty bands, forming a ridge near Old Radnor were considered by Sir Roderick Murchison to be May Hill Sandstone. The author has discovered that one of the beds of Woolhope Limestone, dipping westward, is crowded with rounded and angular fragments of grit bearing a general resemblance to the arenaceous parts of the Old Radnor Group. The bedding of the grits is much obscured by crushing, and the rock is sometimes brecciated. Descriptions of microscopic sections of the rock are given in the paper, and the specimens are grits, the materials of which are mainly derived from gneissic and igneous rocks. The unconformity of the grits to the Woolhope Limestone Series, and the dissimilarity of the grits to the May Hill Sandstones of Presteign are the chief facts relied upon by the author to establish the pre-Cambrian age of the Old Radnor Series; while the occurrence of the rocks on the strike of the Longmynd, their position with regard to the prolongation of the Church Stretton Fault, and their relations to the Ordovician and Silurian rocks of the area are in favour of a comparison with the Longmyndian rocks. The lithological resemblances between the Old Radnor Series and the typical Longmyndian are very well marked. Neither the rocks of the Old Radnor Series nor those of the Woolhope Series are affected by any metamorphic change.

The grits and shaly beds of Huntley are unlike the May Hill Sandstones of that district, and as they occur along the axis of the anticline, and lithologically resemble the rocks of the Longmynd, it is highly probable that they also are of Longmyndian age.

IV.—May 9, 1900.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "The Pliocene Deposits of the East of England. Pt. II: The Crag of Essex (Waltonian), and its Relation to that of Suffolk and Norfolk." By F. W. Harmer, Esq., F.G.S. With a Report on the Inorganic Constituents of the Crag by Joseph Lomas, Esq., F.G.S.

The term 'Red Crag,' including, as it does, beds differing considerably in age, is vague, and, when we attempt to correlate the East Anglian deposits with those of other countries, inconvenient;

the Scaldisian zone of Belgium, for example, with its southern fauna, representing one part of it, and the Amstelian of Holland, in which Arctic shells are common, another. While retaining the name for general use, therefore, the following more definite classification of its various horizons, and of those of the English Pliocene generally, is proposed :—

NEWER PLIOCENE.		
CROMERIAN.	So-called Forest-bed Series. Fresh-water & Estuarine.) Zone of *Elephas meridionalis.*	
WEYBOURNIAN.	Weybourn and Belaugh Crag. Zone of *Tellina balthica.* (Marine.)	
CHILLESFORDIAN.	Chillesford Clay and Sand. Zone of *Leda oblongoides.* (Estuarine.)	
ICENIAN.	Norwich Crag. (Marine.) Northern part: Zone of *Astarte borealis.* Southern part: Zone of *Mactra subtruncata.*	
BUTLEYAN.	Red Crag of Butley and Bawdsey. Zone of *Cardium grœnlandicum.*	AMSTELIAN. Upper part.
NEWBOURNIAN.	Red Crag of Sutton, Newbourn, Waldringfield, etc. Zone of *Mactra constricta.*	Lower part.
?	Red Crag of Bentley & Tattingstone.	
WALTONIAN.	Crag of Essex. Oakley horizon: Zone of *Mactra obtruncata.*	POEDERLIAN.
	Walton horizon: Zone of *Neptunœa contraria.*	SCALDISIAN. Zone à *Trophon antiquum* (*Chrysodomus contraria*).
GEDGRAVIAN.	Coralline Crag. Zone of *Pecten Gerardii.*	CASTERLIAN. Zone à *Isocardia cor.*
OLDER PLIOCENE.		
LENHAMIAN.	Lenham Beds. Zone of *Arca diluvii.* Boxstone fauna.	DIESTIAN. Ferruginous sandstones of Diest. Waenrode Beds.

The line separating the Older and Newer Pliocene is now drawn by the author between the Lenham Beds, containing *Arca diluvii* and other characteristic Miocene species of the North Sea (or of the Italian Pliocene), and the Coralline Crag, the latter being considered as the oldest member of a more or less continuous and closely connected series of Newer Pliocene age. The palæontological difference between the Coralline and Walton Crags is shown to be less than has hitherto been supposed.

The upper Crag deposits arrange themselves in horizontal and not in vertical sequence, assuming always a more boreal and more recent character as they are traced from south to north. They are the littoral accumulations of a sea retreating, not continuously, but at intervals, in a northerly direction.

A new horizon of the Crag, represented by some beds at Little Oakley, between Walton and Harwich, is described, indicating the period, before the southern mollusca had commenced to disappear, when a few boreal species were beginning to establish themselves in greater or less abundance in the Anglo-Belgian basin. Though hitherto unnoticed, the fauna of this locality has proved to be exceedingly rich, more than 350 species and varieties having been there obtained, from a seam 10 yards long and less than 2 feet in average thickness.

The three divisions of the Red Crag now proposed (the exact position of the Bentley bed not having been ascertained at present), namely, Waltonian, Newbournian, and Butleyan, are distinguished alike by the difference of their faunas and by the position which they occupy. The first, with its southern shells, is confined to the county of Essex; the second, containing a smaller proportion of southern and extinct, and a larger proportion of northern and recent species, occupies the district between the Orwell and Deben, and a narrow belt of land to the east of the latter river; the third, in which Arctic forms such as *Cardium grœnlandicum* are common, is found only farther north and east. All these beds are believed to have originated in shallow and landlocked bays, successively occupied by the Red Crag sea as it retreated northward, which were silted up, one after the other, with shelly sand.

The Norwich Crag (Icenian) occupies an area entirely distinct from that of the Red Crag, no instance being known where the one overlies the other in vertical section; the fauna of the former is, moreover, more boreal and comparatively poor in species. The Arctic species, *Astarte borealis*, is confined to the northern part of the Icenian area; its introduction seems to mark a stage in the continued northerly retreat of the sea. The Icenian deposits thicken rapidly northward and eastward, and are believed by the author to constitute part of the great delta-formation of the Rhine.

The mammalian remains found at the base of the different horizons of the Crag in a *remanié* bed, containing material derived from various sources, are considered to be also derivative from deposits, older than the Coralline Crag, formerly existing to the south.

The Chillesfordian (estuarine) and Weybournian (marine) deposits,

the latter characterized by the sudden appearance in the Crag basin, in prodigious abundance, of *Tellina balthica*, represent separate stages in the continued refrigeration of East Anglia during the Pliocene period; but the so-called "Forest-bed" or Cromerian (fresh-water and estuarine) with its southern mammalia, and its flora, similar to that of Norfolk at the present day, clearly indicates a return to more temperate conditions, and should therefore be separated alike from the Weybourn Crag on the one hand, and from the *Leda myalis* Sands and the Arctic fresh-water bed of Mr. Clement Reid on the other. The two latter seem naturally to group themselves together, and with the Glacial deposits.

The conditions under which the Red Crag beds originated seem to exist at the present day in Holland, where sandy material brought down by rivers, with dead shells in great abundance from the adjacent sea, is being thrown against and upon the coast, principally by means of the westerly winds now prevalent. From meteorological considerations, it seems probable that strong gales from the east may have prevailed over the Crag area during the latter part of the Pliocene epoch. No other explanation of the accumulation of such vast quantities of dead shells on the East Anglian margin of the North Sea at that period can be suggested. At the present day, the eastern shores of Norfolk and Suffolk are almost destitute of such débris.

Mr. J. Lomas, in his Report on the Inorganic Constituents of the Crag, states that lithologically the various subdivisions of the Red Crag are the same. Differences of colour may be traced to definite lines of flow along which water containing ferruginous matter has moved.

Among the rarer minerals separated out by high-density fluids, zircon, rutile, cyanite, ilmenite with leucoxene, garnets, andalusite, corundum, tourmaline, muscovite, biotite, glauconite, orthoclase, labradorite, albite, and microcline are found. In the heavy fractions red garnets are very common. Tourmaline occurs abundantly, and includes green, blue, yellow, and brown varieties. Muscovite predominates over biotite, and often includes rounded crystals of zircon, rutile, etc. Ferro-magnesian minerals, with the exception of biotite, are absent. Glauconite is very plentiful, and frequently retains the form of the organisms of which it has formed casts.

In the Norwich Crag the same minerals are present, but muscovite is found in excess. The Chillesford Sands differ from the Crags only in the absence of glauconite. The bulk of the material of the beds described consists of well-rounded grains of quartz, seldom showing traces of secondary crystallization. Flint occurs as large pebbles, and fine angular chips are met with in the sands.

2. "A Description of the Salt-Lake of Larnaca in the Island of Cyprus." By C. V. Bellamy, Esq., F.G.S., Assoc. M. Inst. C.E.

After a brief description of the general geology and geography of the island the author proceeds to deal with the topography of the Lake, which occurs in a basin shut off from the sea, its deepest part being about 10 feet below sea-level. The barrier between the salt-

lake and the sea is made of stiff calcareous clay associated with masses of conglomerate resting on plastic clay, that on watery mud, and that again on stiff calcareous clay. The sea-water appears to percolate through the highest deposits, meeting with checks in the conglomerates, and thus reaches the basin somewhat slowly, where it is evaporated to dryness by the summer heat and deposits its salt. Artificial channels have been made, to carry the flood-water from the land direct to the sea, so that it does not dilute the brine of the lake. The rainfall in the catchment-area round the lake is at the most only enough to supply 223 million gallons, and as the lake contains 480 million gallons when full, the balance of 257 million gallons must be derived from the sea. The lake is probably situated on what was an extensive arm of the sea at the close of the Cainozoic era. The salt-harvest begins in August, at the zenith of summer heat, and it is reported that a single heavy shower at that time of year suffices to ruin it. Observations are given on the density of the water, the plants and animals in the water, and the lake-shore deposits.

CORRESPONDENCE.

SHELLS FROM PORTLAND RUBBLE DRIFT.

Sir,—May I ask a few lines space to add to the list of Land and Fresh-water Shells from Portland Bill Rubble Drift recorded in my previous letter (Geol. Mag., Dec. IV, Vol. I, 1894, p. 431).

After about three hours' work there on Feb. 21st last among the numerous shells of species already recorded, I found the following new species: *Helicella itala*, 2 specimens; *Limnæa truncatula* (dwarfed variety), 4 specimens. These identifications have been kindly endorsed by Mr. Edgar A. Smith, F.Z.S., of the Zoological Department, British Museum (Natural History).

On carefully going over the specimens with Mr. B. B. Woodward and Mr. A. Santer Kennard, two other species must be recorded, viz., *Helix*, sp. (protoconch of an indeterminable species), and *Hygromia rufescens* (Pennant). The relative abundance of the species, as found by me, is as under, adding previously recorded finds (Geol. Mag., 1894, pp. 431, 432) to those of February 21 last (new records are in italics):—

Helicella itala (Linn.)	2	spec.
Hygromia hispida (Linn.)	1	„
Hygromia rufescens (Pennant)	10	„
Vallonia pulchella (Müll.)	5	„
Helix, sp.	1	„
Pupa muscorum (Linn.)	84	„
Succinea oblonga, Drap.	50	„
Limnæa pereger (Linn.)	22	„
Limnæa truncatula (Müll.)	16	„
Pomatias reflexus (Linn.) [=Cyclostoma elegans (Müll.)]	1	„
Pisidium, sp.	1	„

The numbers of Sir Joseph Prestwich's specimens are not stated, but the above table is probably the order of frequency of occurrence.

Mr. E. R. Sykes, F.L.S. (President Conchological Society), has found *L. truncatula* in a deposit on the east side of the Isle of Portland. He considers this latter deposit as comparatively recent, and derived from a marshy tract which still exists south of Southwell. If this be so the deposits are not synchronous, inasmuch as the geological conditions of the deposit at the Bill are well defined as of late Pleistocene age, not only from the stratigraphical evidence, but from the abundant occurrence of so characteristic a Pleistocene form as *S. oblonga*. Mr. Sykes (Proc. Dorset Field Club, vol. xvi, p. 171) records *L. truncatula* from the 'Bill' deposit. On referring to Prestwich's paper on the raised beaches (Q.J.G.S., vol. xlviii, 1892, p. 278) *L. truncatula* is determined *from the occurrence of opercula only*. Probably *Bythinia tentaculata* is meant, as it occurs also at Chesilton at the north-west of Portland, and is an operculate mollusc, whereas *Limnæa* is non-operculate (Reeve, "British Land and Fresh-water Mollusca," 1863, p. 154). This inadvertence may be a *lapsus calami*, either on the part of our author or of Dr. Gwyn Jeffreys, who generally determined doubtful or critical species for him.

Limnæa truncatula is therefore still a new record from this interesting Pleistocene deposit. R. Ashington Bullen.

Axeland, Surrey.

THE CENOMANIAN OF BAHARIA OASIS, EGYPT.

Sir,—I have to thank Dr. Max Blanckenhorn for his letter in the Geol. Mag., April, 1900, p. 192, disclaiming to have himself "discovered the existence of rocks of Cenomanian age in Baharia Oasis." As Dr. Blanckenhorn maintains that he cannot be held responsible for the abstract report which appeared in the *Zeitschrift für praktische Geologie*, I should like to point out that the copy of this abstract report was sent to the Survey by Dr. Blanckenhorn himself, and although it contained numerous corrections in ink of the type matter, the paragraph to which exception was taken, and which I quoted in my letter of December 7, 1899, was not in any way corrected or explained; I could therefore only come to one conclusion.

As I have already stated my opinion as to the age of the series of beds under discussion, both in my letter of December 7, 1899 (Geol. Mag., January, 1900), and in a paper read before the Cairo Scientific Society in October, 1899, it is not necessary to discuss Dr. Blanckenhorn's assertion that I did not "know the meaning" of the fossils collected, especially as this has nothing to do with the question in dispute. Moreover, as the examination of these fossils has not yet been completed by the palæontologists of the British Museum, the exact horizon or horizons to which they should be referred cannot possibly be indicated with certainty.

Cairo, *April* 14, 1900. Hugh J. L. Beadnell.